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# ***JPRS Report***

# **Science & Technology**

***CHINA: Energy***

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# Science & Technology

## China: Energy

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### Energy Expert Addresses Nation's Inefficient Use of Resources

906B0045A Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 31 Jan 90 p 1

[Article by Zheng Tianfen [6774 3944 5358]: "Energy Expert Xie Xingjian [6200 5887 0256] Spoke on the Alleviation of Energy Shortages: 'Develop Holistic Energy Systems To Provide Inexpensive Electricity'"]

[Text] Since China's Second 5-Year Plan, energy has always been in short supply. At present, because of energy shortages, not only is civilian life directly affected, but productivity of some factories has also been hampered. In order to solve this serious problem, Xie Xingjian, the energy expert who had proposed daylight-saving time in China, recently made the following suggestion. In addition to increasing the building of basic energy industries, it is imperative to depend on scientific and technological advances to raise China's rate of energy utilization. One important policy is to develop holistic energy systems to provide inexpensive electricity, hence alleviating the shortage of electricity. His suggestion has attracted the serious attention of authorities.

Xie Xingjian pointed out that China is the world's worst squanderer of energy. In terms of per-capita energy productivity, it exceeded India by 100 percent. Optimistic estimates of China's rate of energy utilization is a mere 28 percent. To solve the energy crisis requires strategies in promoting the idea of energy economic benefits. The distinctive feature is its local applicability; using the least investment for maximum production. The model for achieving the above strategy is the development of holistic energy systems.

Xie Xingjian defines holistic energy utilization as the combination of the use of both material energy and quantity of energy. In China, most of the energy enterprise consumers have some problems in the use of energy materials and energy quantity. For example, 100°C is all that is needed for families' energy uses such as heating, bathing, and cooking. However, the fuel provided can generate extremely high heat values. Using 1000°C of heat to produce 100°C hot water is using high energy for low-level production. Another example is that more than 90 percent of the electrical plants in China produce electricity as their only product using a condensation process. Although these electrical plants produce high-quality electricity, the rate of high-energy utilization is only 30 percent. Huge amounts of potential energy in the form of steam are neglected because of its low temperature. The steam becomes waste products and is released into water and the atmosphere (this comprises 60 percent of the wasted energy). This practice not only wastes energy but also pollutes the environment. If actions can be taken in the stepwise utilization of energy to recover energy materials and energy quantity, the economic and social benefits produced will be immeasurable.

Then, Xie Xingjian described the situation of the holistic production system of Qinghua University. Since 1982, existing furnaces were converted to supply heat and generate electricity for use in a small-area holistic production system.

Electricity used to supply heat to Qinghua University in the winter is approximately one-fourth of the total electricity consumption. Therefore, winter electricity supply is even more critical. The combined heat and electricity production system extracts high-quality energy to generate electricity from the heat-supply furnace. The low-temperature latent heat that is expelled is then used for heating. This strategy fully utilizes the latent energies, and produces large amounts of inexpensive electricity. This system has been safely implemented in the last 4 years. It has generated more than 20 million kilowatt-hours of electricity, each unit costing only 3 fen. Not only does this guarantee the electricity used by the furnace-room, it also alleviates the electricity shortage of the entire campus.

In comparison with regular heat-supply systems, the combined heat and electricity system has many advantages. For example, it changes the furnace-room from a costly consumer of electricity to an electricity-generating enterprise using electricity generation to produce heat. This turns a sole state-subsidized installation into a profit-making enterprise. The appropriate coupling of heat and electricity production can maximize the generation of electricity. The system heat ratio is also higher than traditional heating mechanisms. The temperature of the heating medium has overcome traditional standards in that room temperature is used as the basis of control. The system is operated by controlling the flux of heat according to the difference between the low temperature and room temperature. Since the electricity generated each winter costs 500,000 to 1 million yuan, the complete implementation of the system of generating electricity from heat, and producing heat in the process of electricity generation, meant that the remodeling costs had been recovered in 2 years.

Xie Xingjian thinks that northern China is extremely cold in the winter and is equipped with large numbers of heat furnaces. Putting into practice the combined production of electricity and heat in small areas will no doubt alleviate winter electricity crises, improve the quality of heat supply, increase economic benefits, and reduce environmental pollution. In southern China the summer is extremely hot, and the combined production of air-conditioning and electricity also has a bright future. The many industrial and mining establishments in China that use heat and steam throughout the year can convert to combined heat and electricity production systems. The result will be full utilization of energy resources and the alleviation of electricity supply. Towns and villages can also convert to combined heat and electricity production. Not only can this resolve the problem of less of working hours due to electricity shortages, but also provide energy to be adequately applied toward agriculture and animal husbandry.

Therefore, rapid implementation of holistic energy systems will have profound effects on China's industrial and agricultural production as well as energy conservation.

### **Energy and the Environment: Technological Advances of 1990's**

906B0045B Beijing KEJI RIBAO [SCIENCE AND TECHNOLOGY DAILY] in Chinese 31 Jan 90 p 2

[Article by Wang Hanlin [3769 3466 2651]: "Energy and Environmental Protection—Professor Chen Mingshao [7115 2494 4801] Discusses Technological Advances of 1990's"]

[Text] In 1975, Premier Zhou Enlai issued a directive to carry out the technological task of eliminating smog. This directive reached Professor Chen Mingshao, then state Political Commission member and "9.3 study group" central vice chairman. From that time on, this engineering fluid-mechanics expert labored 15 years in the fields of energy and environmental protection and made substantial contributions to China's energy and environmental protection systems. The reporter asked him to discuss China's technological advances in the 1990's. Of course, his topics revolved around these two problems.

"In order to talk about the 1990's, first we have to clarify what year the 1990's begins at. This question has been debated in the world. Recently, the Chinese Measures and Units Technology Commission clearly stated that beginning in 1990, the world has entered the 1990's."

"In order to predict technological advances, we have to discuss China's advances in the four modernizations. In reviewing the advances in China in the last few years, the factor is energy resources. In general, China's economy cannot develop without energy resources. At present, the discrepancy between supply and demand is enormous. The total electricity-generating capacity in China and the total electrical appliance capacity has reached a ratio of about 1:3. At present, the average electrical installed capacity per capita is 3 kilowatts in the United States, 2 kilowatts in France, 1 kilowatt in Japan. In China it is only 0.1 kilowatt. By the year 2000, China's total installed capacity will reach 240 million kilowatts. The per capita installed capacity will be 0.2 kilowatt.

"At present, China has long been involved in 'a battle between water and fire.' The question has been whether to use coal or water to generate electricity. By the year 2000, China's coal production can reach 1.4 billion tons. At present, electricity produced by coal is 20 percent of total coal production. Ten years from now, if 400 million more tons of coal is produced and half of that is used to produce electricity, the total installed capacity can increase only by 70 million kilowatts."

China's hydroelectric power resources rank first in the world. However, they have not been developed and well utilized. Using only Sichuan as an example, Professor

Chen placed a map of that province on the tea table. He pointed to Jinsha Jiang, Yalong Jiang, and Min Jiang and remarked to the reporter:

"The theoretical potential hydropower resources in Sichuan are 150 million kilowatts. The installed capacity that can be developed is 91.66 million kilowatts. However, at the end of 1988, the hydropower plant installed capacity of the whole province was only 3.06 million kilowatts, or 3.3 percent [of the potential]. It is only 8 percent in the entire nation. It is a pity that such valuable resources are going to waste. In the 1990's, China should fully utilize hydropower resources, and spend much effort in this area.

"Solar energy is an inexhaustible and completely non-polluting source of energy. In the last few years, other countries have achieved major developments in the utilization of solar power. In China, there have also been some breakthroughs. For example, China has begun to use the solar furnace, solar water-heater, and the solar room. In recent years, the technology of direct transformation of solar power into electrical power has made epic advances and it awaits for China to develop and study this area.

"In general, there are two kinds of energy. One is exemplified by coal, natural gas, petroleum and the like, that are non-renewable energy sources. The other kind is exemplified by solar, wind, and tidal processes, that are [renewable] energy resources. In the 1990's, clean renewable energy sources should continuously be used to replace the consumable energy sources that are also polluting."

Regarding environmental protection, Professor Chen has the following to say: "Whenever we talk about environmental protection, people naturally think of working to protect the environment and environmental health. Actually those are short-term emergency procedures only. When we talk about environmental protection we talk about major issues that benefit succeeding generations such as how to protect humans from getting cancer, contracting abnormalities and deformities. In order to develop socialistic environmental protection that is specific to China, three areas have to be tackled simultaneously. Economic benefits, urban-rural development, and environmental protection have to be synchronized. Economic benefits, social benefits, and benefits to the ecological environment have to be equally emphasized. Also, environmental protection and economic development projects have to be designed, constructed and operated at the same time. China's environmental pollution has become quite serious: the greenhouse effect, acid rain, thinning of the ozone layer—even diseases eradicated many years ago such as typhoid, dysentery and other diseases transmitted through water are making a comeback. These are challenges in the 1990's; these are major issues in technological advances in the nineties."



### Issues Faced by Energy Industry in 1990's

906B0045C Beijing JINGJI RIBAO in Chinese  
3 Feb 90 p 2

[Article by Xie Ranhao [6200 3544 3185]: "Energy Industry, the Nineties Beckons You"]

[Text] "The eighties was a significant period of development. However, we cannot be blindly optimistic. The nineties is a period of hard work and the situation is still serious. The energy industry needs to make further advancements."

That was the conclusion of more than 300 Chinese energy experts when they convened early this year in Beijing to discuss China's plan for energy resources development.

In review, in the past 10 years China can boast of a rapid energy industry development. In the decade between 1980 and 1989, consumable energy source production of standard coal increased from 637 million tons to 1 billion tons, a net increase of 363 million tons; the annual rate of increase is 4.3 percent. Of this, carbonaceous coal increased from 620 million tons to 1.04 billion tons, an annual average increase of 42 million tons. Petroleum increased from 105 million tons to 137.6 million tons, a net gain of 32.6 million tons, an annual average rate of increase of approximately 2.7 percent. Electricity generated from reusable energy sources rose from 300.6 billion kilowatt-hours (kWh) to 580 billion kWh, a net increase of 279.4 billion kWh and an annual average rate of increase of 7.8 percent. Of this, hydroelectrically generated power rose from 58.2 billion kWh to 116 billion kWh, doubling the amount produced 10 years ago.

Because of the above-mentioned achievement, China has now become the third largest energy producer in the world.

As the 1990's arrives, the responsibility shouldered by the energy industry also increases.

According to the total rate of increase of 7.7 percent of China's industrial and agricultural production, even with considerations given to technological advances and the possibility of conservation, China's total need for consumable energy sources to develop economically will reach 1.43 billion tons of standard coal by the year 2000. Of this, raw coal production comprises 1.4 billion tons, crude petroleum comprises 200 million tons, natural gas comprises 30 billion cubic meters, hydropower comprises 90 million tons of standard coal, nuclear energy comprises 12 million tons of standard coal, and electricity generated from reusable energy sources comprises 1200 billion kWh.

These goals are grand indeed. However, by the year 2000, as China's population reaches more than 1.2 billion, even when the above goals have been achieved, the annual average per-capita consumption of consumable energy will only be a little more than 1 ton of

standard coal. The per-capita electricity consumption will only be 1,000 kWh. This still will be 60 percent and 50 percent of the current world averages. The per-capita energy and electricity consumption is very low. However, to achieve the above-mentioned goals is not an easy task. In addition, the inadequacies in the development of the energy industry in the eighties further compound the problem.

In the 1980's, adequate macroscopic control was lacking, the economy was overheated, energy requirements for production and living rose much too quickly, and the rate of energy waste was too high. Because of these and other reasons, China's energy-supply situation has been extremely critical. The situation became even more desperate after June 1988. In the four corners of the nation, there were shortages in coal, petroleum, and electricity everywhere. After some regulating and readjustments in 1989, as China's industrial growth receded and the production of coal ores and generated electricity both reached the goals of the Seventh 5-Year Plan 1 year ahead of schedule, the nationwide energy crisis ameliorated somewhat. However, the situation of total energy demand far exceeding total energy supply has not fundamentally changed.

At the same time that energy supply and demand became critical, the various sections of the energy industry also appeared weak in progress, slow in growth, and imbalanced.

**Coal industry:** At present, it takes an average of 10 years to build a pair of medium-to-large-scale mines in China. The end of the 1980's, i.e., the first 4 years of the Seventh 5-Year Plan, was a period of inadequate investment. Speaking only of the situation of "State-Operated" standard ration coal ores, few mines were started which would mine more than 80 million tons of coal, and produce more than 45 million tons of coal. This represented only 40.1 percent of the planned mine construction, and 65.7 percent of planned production level. This means that during the 1990's, in the late years of the Eighth 5-Year Plan, China will essentially have no new mines to start production. The Ninth 5-Year Plan will be a hiatus in coal mining development.

**Petroleum industry:** After many years of drilling, the natural tendency of gradual reduction of petroleum is an irreversible situation. In the 1980's, the major oil fields in eastern China which had produced more than 60 percent of China's petroleum were showing a tendency of reduced production. This led to the rapid reduction of the net increase of petroleum production in the succeeding years. Petroleum production increased by 5.78 million tons from 1985 to 1986, 3.45 million tons from 1986 to 1987, 3 million tons from 1987 to 1988, and a mere 600,000 tons from 1988 to 1989. At this rate of absolute tonnage increase, the net gain was eight-ninths strong in the 4-year period.

At the end of the eighties, the exploration from petrol and natural gas in northern and central Xinjiang Tarim

Pendi produced significant breakthroughs, and it seemed possible to obtain from that region new oil fields. However, in order to really achieve production capacity and large-scale oil drilling is not an easy task, one that cannot be measured in terms of a few years. Therefore, reserves that have been ascertained now but not yet drilled can only provide petroleum to supply for a little over 1 year.

**Electric-power industry:** In about 80 percent of the coal-powered electrical plants in China, one-fourth of them are middle-to-low-voltage power plants that are also low in efficiency and high in fuel waste. Some of these plants have already exceeded their planned years of service. Also, there have been many electrical networks built in urban and rural areas, thus adding to the problem of insufficient electrical power supply as restructuring far exceeds electricity power-plant construction. The safe generation of electricity has now also been affected to varying degrees.

Furthermore, according to the need to double the amount of electricity generated by the year 2000, China's generator capacity has to increase from the present 124 million kilowatts to 240 million kilowatts. It is rare to be able to achieve this in 10 years anywhere in the world. Besides, China has to be restricted by the requirement to standardize the structure of electrical energy generation. At present, nuclear power is in its early years. Therefore, by the year 2000, its proportion will not be very much. Petroleum has to be used mainly as industrial raw material or fuel for machinery. This points to the conclusion that the principal sources of energy for electricity generation are coal and hydropower. Coal-generated electricity at present accounts for 20 percent of the total coal production in China. By the year 2000, China's coal production will reach 1.4 billion tons, an increase of 400 million tons from the present level. If one-fourth of this is used for power generation, we can only add 30-40 million kilowatts. Even if half of this is used to produce electricity, the increase is only 70 million kilowatts. However, the constraints imposed on coal usage by transportation and other industries will no doubt reduce this amount. Therefore, in order to increase 120 million kilowatts of electricity, 50 million kilowatts have to come from developing hydropower. This means that every year, 5 million kilowatts of hydroelectrically generated power has to be produced. But in the later years of the Seventh 5-Year Plan, hydroelectrically produced power dropped continuously in proportion to the total electricity production. There is also a limitation in realizing hydropower in the long period of time needed to construct hydropower plants. Meeting the goal of electrical energy production is indeed very, very difficult.

Summarizing the above, experts feel that in the 1990's, China's energy industry will face a more serious situation than in the 1980's.

The task is extremely difficult and the situation is serious. However, Zou Jiahua [6760 1367 5478], State

Council Commission member and State Planning commissioner, said that China's economic development strategy of following "the three steps" cannot change. All economic tasks need to be considered and revolve around this goal. Energy industry development has to revolve around this goal as well.

Experts feel that in order for China's energy industry in the 1990's to build on the basis of the 1980's, to continue to develop in a healthy manner, and to fulfill the need of doubling China's national economy by the year 2000, the energy industry has to rise to a higher level. Otherwise, after revitalization and reorganization, as various sectors of business and industry progress on a healthy path, China's energy supply-and-demand problem will become one different from that in the 1980's, namely, the crisis of a drop in energy production. In order to prevent this from happening, it is important to deal with the symptoms as well as the root of the problem. The most important task at present is to concentrate on implementing three areas of work.

Deepening reorganization means continuing to insist on and perfect the bearing of responsibility for business undertakings in various enterprises. Especially important is the system of responsible undertakings in the area of coal, petroleum, electricity, and other enterprises. When proven by experience, what is beneficial to mobilize enterprises and their employees to promote enthusiasm in production should be insisted upon. At the same time, we should proceed with unified undertakings, seriously summarize experience, develop pluses and eliminate minuses, and stress perfection. This is especially important now with enterprises showing losses or diminished gains due to unrealistic pricing of energy products. These enterprises cannot even maintain simply reproduction of their products. This situation has to change.

Energy is the lifeblood of the national economy. Capital is the lifeblood of the energy industry. For the energy industry to strengthen, China should follow the policy for enterprises and capital: redirect investments to help solve the problem of insufficient capital in the energy industry, especially in coal and petroleum. This will strengthen its development potential. At the same time, continue to mobilize the enthusiasm of various enterprises to pool resources to engage in the development of the energy industry, and encourage enterprises to utilize foreign capital as long as they can repay the principal and interest.

Strengthening control means obtaining potential and benefits from control. Energy enterprises are usually ones that are concentrated in capital. The potential for increasing productivity while saving resources is huge. Enterprises should strengthen their invested capital, regulate according to amounts, and elevate the quality of employees and technicians. The goals are to shorten construction time and lower project unit costs. It is necessary to strengthen labor and simplify to eliminate unnecessary management personnel. Enterprises have to

develop into multi-faceted businesses. Based on the current standards of efficiency and benefits, which are the best in the industry's history, we need to improve and exceed the world's advanced standards. Some of these goals can be achieved without spending money; some still would need capital.

### Rural Energy Resource Development Studied

906B0037A Beijing BEIJING KEJI BAO [BEIJING SCIENCE AND TECHNOLOGY NEWS] in Chinese  
29 Nov 89 p 3

[Article by Deng Keyun [6772 0668 5686]: "Seeking the Correct Route for China's Rural Energy Development"]

[Text] The idea of agricultural engineering was once again raised when China implemented reform and opening to the outside world. It guided us in applying the methods of systems engineering, consistent with the current level of science and technology, to an examination of China's agricultural problems and an analysis of what needed to be overcome and what needed to be developed in order to achieve the objectives of agricultural modernization. But the worldwide energy crisis of the 1970's quickly heightened people's energy consciousness. The intersection of these two factors revealed many realities, providing food for thought and indicating that China's countryside had serious energy problems.

#### 1. The Experts Sound the Call

The China Agricultural Engineering Society was founded in November 1979, and set up a special group on rural energy; the China Energy Society held its preparatory meeting (at Hangzhou) in December of the same year. Thereafter, at a series of national-level academic conferences, experts headed by Yang Jike [2799 4764 3784], Wu Xianggan [0702 3276 3227], Shao Huijian [6730 6540 1017], and Huang Zhijie [7806 1807 2638] sounded the alarm about shortages of energy for daily life and production in the countryside, the use of backward technology there, and the adverse ecological consequences for agriculture that were resulting.

China's peasants feed 22 percent of the world's population with 7 percent of the world's arable land and in addition must support China's economic development. What amount of agricultural output and what energy investments are required for such a historical mission? How can we rectify the rural energy shortages and wastage of resources?

#### 2. Organized Policy Studies

In the early 1980's, the old State Agricultural Commission and the State Science and Technology Commission set up the Rural Energy Policy Study and the Rural Energy Resource Districting Methods Study, which were the beginning of organized policy studies.

In the early 1980's, China's rural energy situation was as follows.

a. Rural energy use had a markedly diversified structure and included both commodity energy resources (coal, oil, and electricity) and noncommodity energy resources (straw, firewood, manure, solar energy, and the like), and there was great geographic nonuniformity of resource distribution.

b. The level of energy consumption was low. Total rural energy consumption was 340 million tons of standard coal, of which two-thirds was low-grade biomass (firewood, straw), and rural per-capita use of commodity energy resources was only 140 kg per year, compared with the national level of 600 kg per year.

c. Utilization efficiency was low. Straw-burning stoves for cooking had a heat-conversion efficiency of less than 10 percent, that of coal stoves was 18 percent, losses in the rural power grid exceeded 15 percent, and gasoline consumption by agricultural machinery was universally 18 percent above norm.

d. The rural ecology had already been effected. Two-thirds of the total output of straw (amounting to as much as 240 million tons of material) was used by the peasants as cooking fuel. As a result there was a shortage of feed, and very little organic matter was being returned to the soil, so that its organic-matter content was falling rapidly (it was generally about 1 percent) and its ability to assimilate inorganic fertilizers was being weakened. Fully 200 million tons of firewood and mature timber were used as fuel, and in general there was excessive wood cutting.

In order to find a way of solving the rural energy problems, four national academic conferences were held, with a combined total of 1,100 participants; policy suggestions for rural energy development were gradually worked out in the form of the familiar 16-Character Program: "proceed in accordance with local conditions, mutual supplementation, comprehensive utilization, and emphasis on benefits," together with suggestions on technology policy for the development of various types of rural energy resources.

#### 3. Government Adoption as Current Policy

In 1983 and 1984, a national technology policy evaluation process was set up. Rural energy policy was included in energy technology policy as point 13 of the 16 main points for evaluation, alongside coal, oil, electricity, nuclear power and new energy resources. All of these points were collected into the volume entitled "China Technical Policy: Energy," which was approved by the State Council in 1986 and was issued as a Science and Technology Commission blue book; the state formally issued it for national implementation in 1989.

Significantly, one of the key points singled out for emphasis in the state energy technology policy is "vigorous development of forest energy resources": thus forest energy sources are treated as first-line resources, which was the first time that this had been socially recognized in China. China's long-standing rural energy problem

had constrained and swallowed the results of forestry development, and it was therefore required that the forestry development program take on the social responsibility for providing the countryside with fuel.

As the State Council leadership heard reports on energy technology policy on 31 July 1983, it stated: "The rural energy resources must be treated as a strategic problem, and the solution of rural energy-resource problems must be locally based. The state has a support policy; it must conscientiously put this matter on the agenda and investigate it as a major problem."

In addition, the plans for national economic development in the Sixth 5-Year Plan, published in 1983, incorporated the 16-Character Policy for rural energy development and designated the plans for development of firewood-conserving and coal-conserving stoves, rural household use of methane, small-scale hydropower, and firewood and charcoal forests as state guidance plans. Rural energy development was formally included in the national economic plan for the first time.

#### **4. Noteworthy Results From 5 Years' Implementation of the 16-Character Policy**

Rural efforts to conserve firewood and coal began with the improvement of rural household cookstoves. At present, 90 million rural households are using stoves with thermal efficiencies of 20 percent or higher, and most of them can maintain excellent technical characteristics by replacement of cores and the like; in recent years there has been a move toward conservation of firewood and coal in large rural stoves (catering-industry and school stoves) and small building-materials kilns.

China has gradually mastered the entire methane process technology from fermentation and construction to management and operations and has strengthened training and the supply of standardized materials and parts, with the result that in recent years, development has been steady and the low point has been passed. At present, more than 20 million people (4.7 million households) are using methane as a fuel for lighting and cooking. Methane sludge and methane liquid are superior organic fertilizers and bait, and the peasants have had excellent results in using them to increase output value. This has been a major reason that people have gone into methane production voluntarily and with their own resources.

More than 100 counties have already been designated as rural electrification test counties making primary use of small-scale hydropower. In 1988, the total installed capacity nationwide exceeded 10 million kilowatts, and in that year small hydroelectric stations generated 30.3 billion kilowatt-hours, or about two-fifths of total rural power consumption at the county level and below.

In the last 5 years the central authorities have set up 44 experimental firewood and charcoal forest projects, spread over 21 counties; the objective is experimental screening of multiuse tree varieties and of operating methods. As a result of these projects, in combination

with designation of closed mountain areas for afforestation and the airborne seeding of trees, the area of firewood and charcoal forests has been increased by 42 million mu in the course of 5 years.

In addition, there has been great progress in the use of wind power, solar power and geothermal power in agricultural and stock-raising regions.

More than 70,000 small wind-power installations with capacities of 100 watts or less are already in operation, 60,000 of them in Nei Monggol. They have been extremely effective in providing to peasants and herdsmen in regions lacking a power grid, or with a power grid but no energy resources, with electricity for lighting, television and the like.

The use of solar heating technology has been well received. Water heaters, solar space heating (in residences or homes for the aged), pigsty heaters, driers and the like, were first developed in rural areas of the north. Geothermal resources are used in aquatic products breeding or in seed raising in the north.

To summarize, new energy resources have already begun to produce an effect as supplementary energy sources in the countryside.

#### **5. The Situation in Reform and Opening Up Requires Readjustment and Strengthening of Rural Energy Development Programs**

a. We must attach full importance to conservation of commodity energy resources.

In 1985-87, rural consumption of commodity energy resources showed a considerable increase, accounting for 25 percent of total national energy consumption in 1987; but this increase involved primarily coal. In order to analyze trends in the contribution of commodity energy consumption to total rural energy consumption and to investigate energy conservation technology policy and measures, in 1984-86 the relevant offices set up several very interesting policy-related studies: 1) rural industry energy-use studies and energy-conservation measures; 2) studies of current energy use for agricultural motive power; 3) a survey of the current nationwide status of energy use in agriculture, stock-raising, fisheries and the rest of the five fields under the Ministry of Agriculture, and potential for energy conservation.

The survey results indicated that the consumption of energy resources in rural production in 1984 totaled 116 million tons of standard coal, with firewood accounting for 8 percent of the total; thus the consumption of commodity energy resources for rural production was 107 million tons of standard coal.

Energy consumption by rural industry accounts for 76.8 percent of the total, or fully 89 million tons of standard coal, and the building materials industry accounts for 55.6 percent of energy consumption by rural industry. Because 80 percent of the country's wall brick, 90 percent of its tile, and 100 percent of its lime are



produced and supplied by rural industry, these industries should not be shut down because of their high energy consumption: they should be modernized in order to decrease energy consumption per unit of output. Energy consumption per 10,000 bricks produced by rural industry fell from 1.4 tons of standard coal in 1984 to 1.23 tons of standard coal in 1985; large and medium-size rotary kilns brought their consumption per 10,000 bricks down to 1.0 tons of standard coal, which is a good level for the state-run building materials industry. To solve the problem of recent construction of high energy consumption in small kilns with an annual output of 10,000 bricks built by the peasants themselves, in 1988 a brand-new technology that allowed small kilns to produce 10,000 bricks with a consumption of 0.72 tons of standard coal and wood-burning kilns to do so with 2 tons of wood was made public.

The agricultural machinery and agricultural land-reclamation system is disseminating numerous sets of new gasoline-saving technologies in order to conserve oil.

The state is using technical modernization loans to support energy conservation in rural production.

b. Strengthen large-system thinking, pursue integrated county-level rural energy development programs and practical demonstration projects.

In recent years the rural economy has been developing rapidly, and the magnitude and structure of energy consumption in rural districts have changed markedly. Consumption of commodity energy resources reached 190 million tons of standard coal in 1985, equal to 192 percent of the 1980 figure and representing an annual increase of 18.4 percent, which is far greater than the nationwide annual rate of growth in output of commodity energy resources.

This is a far cry from the early 1980's, when there was special emphasis on solving the problem of energy for living needs by the use of noncommodity energy resources.

The situation is aggravated now, because with the steady improvement of the peasants' economic situation, they have become unwilling to use low-grade cooking fuels.

As a result, the problems of commodity and noncommodity energy resources and of energy for production purposes and domestic use in the countryside require comprehensive consideration and rather high-grade practical technology.

Starting in 1983, the state organized and conducted comprehensive rural energy-development programs and demonstration programs in certain counties. The current situation in the countryside requires that all energy resource development and utilization technologies be subject to comparable project evaluation, competitive ranking, overall planning and integrated development in accordance with resource and economic development objectives, with specification of the rate and scale of the development of practical technologies: this will make it possible to support local implementation of prospective development objectives with the most rational energy investments.

Such systematizing documents as the Methods for Integrated County-Level Rural Energy Development Programs have received a high evaluation from domestic and foreign energy circles and rural development departments and are on a par with the world state-of-the-art.

c. Attach full importance to the development of rural energy industries and service systems.

Since 1984, Comrade Li Peng has repeatedly pointed out on behalf of the State Council the need to establish rural energy industries, to provide the peasants with high-quality, reliable products of various grades, and to provide effective technical services and parts and components supply. The state has provided the rural energy industries with discounted loans on favorable terms and has supported such improvements as new cooking equipment and stoves, methane generators, low-pressure methane lighting equipment and stoves, 100-watt-level wind generators, solar water heaters, building materials for solar heating and the like, which have demonstrated excellent vitality and have promoted standardization and series production of products, so that the rural energy products market has become steadily more vigorous. The output value of operations in 1988 exceeded 500 million yuan, which has accelerated rural energy development.

**Major Investment in Two Hydropower Projects**

40100044A Beijing CHINA DAILY (Business Weekly)  
in English 23 Apr 90 p 4

[Article by staff reporter Huang Xiang; first paragraph is editor's note]

[Text] A campaign to push China forward into the 21st century as an economic power has begun with the launching of 319 large-scale national economic projects since 1982. Starting this week, Business Weekly will report on the progress of 20 of these projects to enable our readers to gain an insight into those that will serve as the powerhouse to fuel the nation's economic take-off.

China is making a major investment in its efforts to build two major hydropower projects in southern and central China where coal is scarce but water is abundant.

Construction of the two power stations is part of the State Council's ambitious plan to build several major hydro stations in those regions by 2000 to promote the nation's modernization programme.

According to the State energy development blueprint, the hydropower sector should generate 240 billion kilowatt hours of electricity in 2000, more than doubling the present output of 116 billion kilowatt hours.

The two projects—the Yantan project on the Hongshui River in Guangxi and the Geheyan project on the Qingjiang River in Hubei Province—will have a total generating capacity of 2.41 million kilowatts. That will equal more than 10 per cent of the generating capacity of all hydro stations now under construction, an official with the State Energy Investment Corporation told CHINA DAILY.

"When completed in 1995, they will significantly lessen power shortages for local industrial and residential consumption," said the official who is with the corporation's General Office.

The Corporation, under the State Planning Commission, is in charge of overall planning and management of state investment in the coal and electric power industry.

China has an exploitable water potential of 378 million kilowatts with two thirds of that in southern and southwest China.

However only 9 per cent of these resources have been tapped so far due to a scarcity of funds.

Experts say it generally takes six to 12 years and may cost up to several hundred million yuan to build a large hydropower station. As a result, the country has been more active in building coal-fired stations.

Many economists believe that China's economic growth is dependent on a power consumption much higher than the world's average.

And now, energy experts warn that the emphasis on coal is backfiring because of the damage to the environment caused by coal mining, transportation and power generation.

For years, the power-restricted regions in central, southeast and southwest China had to rely on electricity from other parts of the country through long-distance transmission lines and numerous substations.

"Besides, coal is almost unrecoverable. So why should not we leave more for future generations to use?" said an energy expert with the State Planning Commission.

"We are also upset by the huge loss of water resources," he said.

Most experts agree that it is especially desirable to build major hydropower stations in Hubei and Guangxi where coal is scarce but water resources remain not fully tapped.

Construction began on the Yantan project in Guangxi in 1984. It is located on the Hongshui River 244 kilometres from the capital city of Nanning.

The main structures comprise a concrete gravity dam 111 metres in height with a spillway section in the middle, a powerhouse at the top of the dam on the right bank and a ship lift on the left side.

As one of the ten proposed projects on the Hongshui River, the 1.632-billion-yuan (\$347 million) project has a capacity of 1.21 million kilowatts and is capable of generating 5.6 billion kilowatt hours of electricity every year.

The first generating unit is expected to be put into operation in July 1992, one year ahead of schedule. The whole project may be completed by 1994.

Experts expect that by then it will relieve much of the power strain in Guangxi, and more importantly, in the neighbouring province of Guangdong where a more developed economy has been plagued by power shortages.

They estimate the project is equivalent to a 14-billion-yuan (\$3 billion) increase in industrial and agricultural output value and a 250-million-yuan (\$53.2 million) increase in profits and tax revenues every year.

For this project, public bidding was introduced in the construction work of a major state project for the first time.

The Geheyan project in central China's Hubei Province is the first in which the investment—a total of 1.6-billion-yuan—is shared between central and local governments.

Located on the lower reaches of Qingjiang River in the western part of the province, the project has a capacity of 1.2 million kilowatts and annual generation of 3.04 billion kilowatt hours.



The Geheyan project is only 50 kilometres southwest of Yichang where the country's largest hydropower station is now under construction.

The powerful Gezhouba Hydropower Station has a capacity of 2.715 million kilowatts. Construction began in January, 1987, and the first of its four 300,000-kilowatt generating units is expected to be put into operation in July of 1993.

The 1.6-billion-yuan investment (\$3.4 billion) in the Geheyan project was shared by the central and provincial government, an approach now widely encouraged by the State Council.

"This is the first time the central departments no longer take fully responsibility for the construction and management of major power projects," an official observed.

The damsite is about 62 kilometres upstream from the confluence of the Qingjiang River with the Yangtze River and controls a drainage area totalling 14,430 square kilometres.

The Geheyan reservoir, with a normal pool level of 200 metres, will have a total storage capacity of 3.4 billion cubic metres, of which 1.3 billion is available for seasonal regulation of the river's water level for flood control purposes.

"The project is truly a multi-purpose development in terms of power generation, flood control, and navigation," said the official with the Ministry of Energy Resources.

When completed, Geheyan can be operated in combination with Gezhouba and will be connected to the Central China Power Network which supplies electric power to Hubei, Hunan and Henan provinces.

[Photo caption] One of the four huge steel tunnels which is being installed at the Yantan Hydropower Station in South China's Guangxi Zhuang Autonomous Region. Each is 69.34 metres in length and 10.8 metres in diameter. The power project, which is to be completed in 1995, has a generation capacity of 1.21 million kilowatts.

**Plant to Power Regional Industry**

40100050A Beijing CHINA DAILY in English  
6 Apr 90 p 2

[Article by staff reporter Huang Xiang]

[Text] The expansion project of a major power plant in Northeast China is expected to provide enough power to industries in the region including Daqing, China's largest oil producer.

With an investment of one billion yuan (\$212 million), the planned project is in suburban Harbin, capital of Heilongjiang Province. It is due to start construction in June, CHINA DAILY learned.

The project, a key one in the central government's current agenda, includes two 600,000-kilowatt generating units in the city's No 3 Power Plant. One of them is expected to be completed by 1993.

The power plant already has two 200,000-kilowatt units.

"The project will be significant to alleviate power shortage for the province's numerous coal mines and Daqing oilfield," said an official with the Ministry of Energy Resources.

Heilongjiang is one of China's major energy suppliers and heavy industry producers.

Hegang, Shuangyashan, and Jixi, all among China's leading mines, produced 40 million tons of coal in 1989.

Daqing, 160 kilometres north of Harbin, still led others in the field with an annual output of more than 5 million tons of crude oil.

But the province, with few power plants, has to depend on its neighbours to support its power industry, which eats up about 50 per cent of local industrial power consumption every year.

In 1988 it supplied over 20 million tons of coal to other provinces, of which 4.6 million tons went to neighbouring Liaoning and Jilin for power generation.

Since 1986 it has to rely on 1.3 billion kilowatt hours of power from outside sources.

With a total capacity of up to 1.6 million kilowatts, experts say the Harbin plant will be one of China's largest coal-fired power plants under construction.

Currently China has its largest completed coal-fired power plant in Jianbi, Jiangsu Province with a capacity of 1.625 million kilowatts.

Situated 29 kilometres north of the city, the planned site of the new plant is reported to be an ideal place for launching a major coal-fired power plant.

On a highland plain which borders on the Songhua River in the east and Hulan River in the south, it has sufficient water supply but will be free of annual floods.

The coal needed will be brought from Hegang and Shuangyashan coal mines.

The investment is shared equally between State and local governments.

### Status, Prospects for CWM Industry

906B0053A Beijing JINGJI RIBAO in Chinese  
12 Feb 90 p 3

[Article by Zhong Jianchun [0112 1696 2504]: "Let 'Liquid Coal' Be Our Industrial Blood—Status, Prospects for CWM Industry"]

[Text] China has been conducting research and development on using CWM (coal water mixture) as a fuel since 1982. After years of experiments, the technology—from preparation, storage, and transportation to combustion—has matured. It is capable of being industrialized and commercialized as a new energy system to replace coal or oil. The pressing matter is to industrialize CWM technology and use it in a wide range of applications. In view of the present energy shortage and the availability of coal in China, this technology will have a tremendous impact on accelerating the economic construction in China. In his visit to the Beijing First Paper Mill to inspect CWM facilities, Zou Jiahua [6760 1367 5478], State Council member and chairman of the State Planning Commission, pointed out that oil consumption must be curbed in view of the present situation. CWM technology has already matured; therefore, we should actively promote its use in order to replace oil with coal.

#### I

Coal is an important energy resource in China. It is more than 75 percent of the energy consumed. The coal industry plays a vital role in the development of China's national economy. High-concentration water coal mixture is a novel oil substitute developed during the oil crises in the 1970's, and one which was seriously examined all over the world after its introduction. A great deal of financial and human resources have been invested by the United States, the USSR and Japan in experimental studies. Major accomplishments have been achieved in the technology itself and in industrial applications.

It is especially significant for China to develop CWM. Because more than 68 percent of the coal deposits are concentrated in northern and northwestern China and less than 5 percent are in eastern and central China, coal has to be shipped from west to east and north to south. Railroad transportation is already heavily burdened with 45 percent of its capacity consumed by coal shipments. The mean distance has risen to 500 kilometers from 200 kilometers in the 1950's. As coal production increases in the future, there is a need to add 20 million tons of railroad capacity every year. The railroads and harbors constructed recently are almost exclusively for shipping coal. If pipelines are built to ship CWM, the shortage in railroad capacity can be greatly alleviated. Next, coal combustion is seriously polluting the environment. Direct combustion of unscrubbed high-sulfur, high-ash coal releases a large amount of ash and sulfur dioxide into the atmosphere, making China one of the worst coal-pollution countries in the world. The type and quality of coal varies over a wide range in China. Sixty percent of the coal is mined in small and medium-size

mines. Approximately 70 percent of these mines do not have coal dressing and screening facilities, resulting in poor quality, low rate of utilization, and waste of precious energy resources. Our inability to solve the coal development and utilization problem has seriously limited our economic growth. Hence, the industrialization of CWM becomes an urgent matter either from the standpoint of tapping into our energy potential or for accelerating the growth of the national economy.

#### II

Do we have the conditions required to industrialize CWM? Based on the information obtained from the China CWM Technology Center, CWM has been listed as a key R&D program by the State Council since the Sixth 5-Year Plan. After years of effort, a great deal of progress has been made. Three experimental centers, i.e., mixture making, pipe delivery, and combustion, have been established. A CWM demonstration project consisting of five plants and six furnaces has been created. This effort has resulted in three major breakthroughs. First, our technology has reached world-class level. We are using an advanced mixing technique which ensures the quality of the CWM. After being shipped in a railroad tank car for several thousand kilometers, there is no deterioration and precipitation. The shelf life is over 3 months. We currently rank fifth in the world in the transport of high-concentration CWM by pipeline. Next, in terms of applications, we are ready for industrialization and commercialization. The mixture-making capacity has reached 120,000 tons per year. It is turning from laboratory research toward industrial applications. Last, we have the capability to handle large-scale engineering design work. The successful development of the CWM demonstration project has provided a basis for the construction of large-scale CWM preparation, delivery and combustion facilities. The CWM Technology Center has completed a feasibility study and preliminary design to convert 27 oil and powdered-coal-burning furnaces to CWM. It is designing and handling the preparation work for the construction of a CWM pipeline between Binxian and the Xianyang Weihe Power Plant in Shaanxi. It is hopeful that a large-scale demonstration project will materialize in the near future to brighten the prospects for the CWM industry in China.

#### III

Despite the fact that we have made remarkable progress in CWM technology, many experts still believe that either its research or its industrial application is still in its infancy. For instance, the mixture-making technique was developed with the objective of replacing oil. It was designed to be shipped by vehicle or boat. Long-range pipeline transport is an important issue. Additional work is required to solve problems such as mixture viscosity, the use of additives, and large-scale dedicated equipment. Furthermore, to use CWM as a complete system, it is also necessary to undergo a complete technical reform from CWM preparation, delivery and furnace combustion. This is an interdisciplinary technology which

requires a high initial investment. Many people shy away because of it. On top of this problem, the constraints in the present system would make it more difficult to promote this technology. In his recent visit to the Beijing First Paper Mill, Zou Jiahua pointed out the need to build a CWM pipeline as soon as possible. This pipeline does not have to be long and large, but it must be built quickly. In view of the fact that there is a shortage of capital in China, we are actively trying to attract foreign investments. General Manager Hao Fengyin [6787 7685 0603] of the China CWM Technology Center disclosed that technical cooperation agreements have been reached with Sweden, the USSR, Italy, and the United States not only to import technology but also to bring in over 10 million yuan of foreign investment. The first large-scale CWM preparation, delivery and combustion demonstration project, the Bin-Wei project, which is a joint venture with the USSR, has made encouraging progress.

The photograph [not reproduced] shows Zou Jiahua (second left) visiting the CWM project at the Beijing First Paper Mill.

### **Construction at Yanzhou Fields Booming**

906B0053B Beijing JINGJI RIBAO in Chinese  
20 Feb 90 p 2

[Article by Zhou Yufeng [0719 3768 1496] and Zhai Zhongquan [5049 1813 3123]: "Fast, Quality and Efficient Construction at Yanzhou Fields"]

[Text] Based on scientific principles, Yanzhou fields in Shangdong, a key national energy construction project, is able to complete a pair of new mine shafts every 6.5 years, put a pair of mines in production every 3 to 4 years, and double its coal output every 5 years.

In a recent meeting celebrating the completion of the Yanzhou fields, experts praised the construction of the extra-large 12.85 million-ton Yanzhou coal fields as the fastest, highest quality, and most efficient coal-related construction project since the founding of the government. It also shows a new way to reduce construction cycles and improve return of investment for the coal industry.

The Yanzhou fields cover Zouxian, Yanzhou and Qufu in Shangdong; they are 475 square kilometers in area. The coal is of excellent quality and the geological deposits are estimated at 3.88 billion tons.

Construction at the Yanzhou fields began in 1971. The total investment is 2.7 billion yuan. The project has taken 18 years and seven pairs of large mine shafts have been completed.

In order to maximize the return on investment, since the very beginning, it was insisted that an overall design had to be done first, to be followed by preliminary design of the mine shaft and other individual projects in a synchronized fashion. Before construction began, a series of

scientific principles such as organization, technology, materials, and preparation was followed. Prior to making every design, a detailed and accurate geologic survey report was made available to the design unit as well. During the design process, in order to make the design more accurate, the geology department and design unit coordinated closely to double-check all inspection drilling sites.

A scientific attitude of searching for perfection also provided a reliable basis for design optimization. The design of the two pairs of mines in Nantun and Xinglongzhuang received a national outstanding design gold medal for the economic layout, highly mechanized production and management, and localized surface construction layout. Through design optimization, construction of Jining No 2, a 4-million-ton-per-year mine, was reduced by 31.1 percent compared to that for similar mines, which shortened the construction period by 2 years.

Scientific design also created conditions to improve construction quality. Seven pairs of mines have been completed in Yanzhou. When they were put in operation, the systems had been perfected and met production capacity requirements. Therefore, they were all rated as excellent projects by the national inspection committee.

Another special feature of the Yanzhou fields is to gain speed and higher returns based on new technology and new techniques. The mines were constructed in multiple sections from several ends. This more than doubled the efficiency of constructing the underground mine shaft. The speed of tunneling was increased by 30 percent by using a new spray-support technique. The well was installed using a mechanized hydraulic molding technique, together with parallel overlapping operation; its construction period was shortened by one-half compared to the conventional method.

The high-speed, high-quality construction of the mines also brings considerable economic benefits to the Yanzhou fields. Between 1971 and 1989, Yanzhou field produced 67 million tons of coal and generated a profit of over 84 million yuan.

### **Jungar Coal Field at Top of Priority Projects List**

906B0040A Hohhot NEIMENGGU RIBAO in Chinese  
8 Dec 89 p 1

[Article by Wang Shoucheng [3769 1343 1004] and Yuan Shaoyi [5373 4801 0034]: "Jungar Coal Field at Top of Priority Projects List"]

[Text] Phase I of the Jungar coal field project has been included as one of the 10 second-batch new key national projects in 1989 by the State Planning Commission. It was also listed at the top of 27 energy-related projects by the State Council. This opens up the curtain for the construction of the Jungar mining area.

The Jungar project involves the comprehensive utilization of coal and electric power. The first phase includes the independently designed and constructed 12-million-ton-per-year Heidaigou modern open coal mine, the 200,000-kW Kengkou power plant, and a 215.6-km single-track electrified railroad. This project is being planned and will be constructed, managed and operated by the Jungar Coal Industry Corporation. It is a new model as a result of the reform of the coal construction system.

The Communist Party Committee and the government of the autonomous region are very serious about this project. Comrades Wang Qun [3769 5028] and Bu He [1580 6378] pointed out in a recently held expanded meeting of standing committee members that the Jungar project will play a strategic role in strengthening the economy and in ensuring sustainable, stable and coordinated growth of the region. They asked for whole-hearted support of the Jungar project. The Jungar Coal Industry Corporation is also taking advantage of the opportunity to undergo a reorganization in order to implement the spirit of the Fifth Central Committee Meeting. The objective is to improve profitability and efficiency and to complete the project within a reasonable time period. To date, Highway No 1 leading to the mine area has been completed. A water supply capable of delivering 10,000 tons of water per day is already in operation. The residential area is taking shape. Highway No 2 and a 220,000-volt high-tension line are under construction. The overall design of the mining area has been reviewed. Key construction projects such as the Heidaigou modern open coal mine, Kengkou power plant and single-track electrified railroad will begin next year. Some officials and technicians have left Wuda, Baotou, Pingzhuang and Huolinghe for Jungar to join the workers at Jungar in the construction of this modern mining area on the Eerduosi Plateau.

### **Huge Inner Mongolian Energy Base Rapidly Taking Shape**

906B0040B Beijing JINGJI RIBAO [ECONOMIC DAILY] in Chinese 29 Dec 89 p 1

[Article by Zhang Shiqing [1728 0013 1987]: "Huge Inner Mongolian Energy Base Rapidly Taking Shape in the North"]

[Text] The energy industry in Inner Mongolia, spearheaded by the 4.1-billion-yuan total investment of the key national construction projects such as Jungar and Huolinhe open coal mines and Dongsheng coal field, is being developed in large scale at unprecedented speed. It will become a sizable energy base in China in the near future.

In addition to 86 million square kilometers of grass field, Neimenggu has 100,000 square kilometers of coal underground. There are 198.22 billion tons of proven coal deposits, which is approximately 22.2 percent of the

total known coal deposits in China. The potential long-range deposits exceed 1 trillion tons. As the layout of China's energy industry is being strategically shifted from south to north and east to west, and as a result of the reorganization of China's industrial structure, the central government has decided to accelerate the construction of Neimenggu as a new energy base. Presently, there are six key construction projects. A total of 7.34 billion yuan has already been committed.

Phase I of the Jungar coal field project has been included as one of the 10 second-batch new key national projects in 1989 by the State Planning Commission. It was also listed at the top of 27 energy-related projects by the State Council. The coal field covers 1,022 square kilometers and has a proven reserve of 26.8 billion tons. The coal layer is 33.65 meters thick. Highway No 1 leading to the mine area has been completed. A water supply capable of delivering 10,000 tons of water daily is already in operation. The residential area is taking shape. A 220,000-volt high-tension line is under construction. Large-scale stripping construction will begin in 1990. By 1992, it will be able to produce 15 million tons (including 3 million tons from local operators). The Huolinhe open coal field is a key construction project in the Seventh 5-Year Plan; it has a production capacity of 3 million tons per year. Recently, the government adjusted its investment plan to speed up the construction process. Within 4 years, its production capacity will increase to 10 million tons. Dongsheng coal field is known for its large deposit, over 80 billion tons, and also for high quality; it is being developed now. By 1992, it will have a 5-million-ton production capacity. The nine government-managed coal mines in the region will have over 30 million tons of newly added production capacity in 1992 and the entire region will have an overall coal production capacity of 60 million tons; this is equivalent to 10 percent of the total coal production capacity of the entire country in 1988. In order to ensure that coal can be shipped to the south and east, the 173-kilometer Baoshen Railroad was opened in October 1989. Construction for the longest local railroad in China, the 943-kilometer-long railroad between Jining and Tongliao, will begin in 1990.

The development of coal also propels the electric-power industry, which is centered around the Kengkou power plant. In 1989 and 1990, Neimenggu will have an additional 1 million kW of installed capacity, which is equivalent to 36.6 percent of the total power-generating capacity built in the past 40 years. Large-scale electric-power-related projects, such as the 2.4-million-kW Dalate power base (a rare large thermal power plant in China), the Yiminhe project, the Jungar project, and the second phase of the Fengzhen power plant, will be constructed in the near future. In the Eighth 5-Year Plan, we will add another 3.5 million kW of installed capacity. By then, we not only can meet the demand within the region but also can deliver power to the power grids in the northeast and northern China.

In addition, petroleum resources in Neimenggu are also being developed at a faster pace. The government invested 870 million yuan in 1989 in the construction of the Erlan oil field, which has a capacity of 1 million tons, and a 365.5-km oil pipeline has been completed. By the middle of December, 300,000 tons of crude oil will be shipped.

### **Big, Modern Dongtan Mine Goes Into Operation**

906B0040C Jinan DAZHONG RIBAO in Chinese  
24 Dec 89 p 1

[Article by staff reporter: "Big, Modern Dongtan Mine Goes Into Operation"]

[Text] On 23 December 1989, the 4-million-ton-per-year Dongtan coal mine of the Yanzhou Mining Bureau, one of the largest vertical mines in China, passed the governmental acceptance check and was officially in operation. Officials from the Ministry of Energy, China Coal Allocation Corporation and the provincial government attended the opening ceremony and issued citations.

The Dongtan coal mine, one of the key projects in the Seventh 5-Year Plan, is located west of Zouxian. Both Beijing-Shanghai railroad and Yan-Shi railroad pass the area. The field is 60 square kilometers in area and the geological deposits are estimated at 810 million tons. The average coal-layer thickness is 10.51 meters. The coal is good for coking and for power.

This modern coal mine is equipped with advanced facilities meeting international standards. A comprehensive excavation approach is used. The advantages include advanced technology, scientific management, complete facilities, and safety and reliability. It is a rare, highly mechanized extra-large mine shaft in China.

The mine was independently surveyed, designed and constructed. Officially, construction began on 1 December 1979. Yanzhou Mining Bureau was in charge of the construction project. It took advantage of the reform to institute an engineering manager-responsibility system and a project contract-responsibility system. In addition, political ideology was strengthened to promote the construction work. At the same time, they imported advanced equipment and technology from abroad, and developed and widely used advanced techniques, such as pre-injection of cement, laser directionality for deep wells, and hydraulic wall molding, to provide extra lift to the construction project.

The operation of this mine marks the completion of the Yanzhou mining area which consists of six pairs of modern mine shafts with a total capacity of 12.85 million tons. It is the first of six major coal bases to be completed. The mine can significantly alleviate the shortage of coal in eastern China and promote the economic growth of the province.

### **Curtain Goes Up on Important Jidong Project**

906B0040D Jinan DAZHONG RIBAO in Chinese  
25 Dec 89 p 1

[Article by staff reporter: "Curtain Goes Up on Important Jidong Project"]

[Text] Construction for Jining No 2 mine shaft, a national key construction project designed to produce 4 million tons of coal per year, officially began on 24 December 1989. Thus, the curtain has gone up on the development of coal fields in eastern Jining. Officials from the Ministry of Energy, China Coal Allocation Corporation, and the provincial government attended the ceremony.

The coal mines are conveniently located east of the city of Jining. To the east is the Beijing-Shanghai railroad, to the west is the Beijing-Hangzhou canal, and to the north is the Yan-Xin railroad. It can easily be reached. The area of coal fields to be developed by the Yanzhou Mining Bureau covers 350 square kilometers and has geological deposits of 2.4 billion tons. The coal layer is flat and stable. The coal is the low-ash, low-sulfur, low-phosphorus and high-heat type, which is suitable for providing power and coking. Yanzhou Mining Bureau was allowed to build four pairs of mine shafts with a total annual capacity of 12 million tons.

The Jining No 2 mine being constructed now is one of the 27 key projects approved by the State Council. It is also the first extra-large pair of mine shafts developed by the Yanzhou Mining Bureau east of Jining. The mine area covers 90 square kilometers and there are 347 million tons of known deposits to be excavated; they are expected to last 67.5 years.

Presently, Jining No 2 has completed construction in terms of electricity, water, roads and communications. In addition, 29,000 square meters of permanent industrial buildings and some living quarters have been completed. Steel frames have been installed and some preparation work has been finished.

### **China Pins Hopes on Coal Province**

40100051A Beijing CHINA DAILY (Business Weekly)  
in English 9 Apr 90 p 4

[Article by staff reporter Huang Xiang; first paragraph is CHINA DAILY introduction]

[Text] Coal has become the major energy resource in China because the country expects to see no major surge in its crude oil output and its nuclear power production is still in the early stages. The country's coal industry is now concentrating its efforts on opening up massive new mines after producing a record 1 billion tons of coal in the past year. Our staff reporter Huang Xiang interviewed some decision-makers in the sector and filed the following report.



With crude oil output veering up and down and nuclear power generation still in the early stages, China is now pinning its hopes on a Shanxi-centred region for a major energy increase this decade.

The region, which includes the whole of Shanxi Province and the part where the northern tip of Shaanxi Province meets the western edge of Inner Mongolia, boasts 60 per cent of the country's proven coal deposits.

The Ministry of Energy Resources expects the region to produce 500 to 600 million tons of coal in the year 2000, or 36 to 42 per cent of its target for the year.

Experts estimate that the region should be able to supply 380 to 400 million tons of coal to other provinces each year by the year 2000.

The Ministry will concentrate on developing huge mines in the region. Some are new mines under construction while others are old coalfields, mostly in the plateau province of Shanxi.

Almost all the experts agree that keeping the old mines functioning may be as important as opening up new ones.

There are half a dozen large old mines in Shanxi and their output reached 100 million tons last year, representing 10 per cent of the country's total.

The Datong Mining Bureau in northern Shanxi alone turned out 34 million tons last year, 10 per cent of the amount produced by the China National Coal Corporation which runs the major State-owned mines.

The Ministry is now stepping up efforts to open up new mines in the region, namely the Shenfu-Dongsheng coalfield in Shaanxi Province, the Jungar coalfield in Inner Mongolia and the Pingshuo coalfield in Shanxi Province.

Located in a remote area of northern Shaanxi Province near Inner Mongolia, the Shenfu-Dongsheng coalfield has 12 separate mines with a total production capacity of 8.1 million tons.

One of them, with an annual capacity of 600,000 tons, has already gone into operation, according to a Ministry official.

Estimated deposits in Shenfu-Dongsheng are more than 230 billion tons in an area of 10,000 square miles. Most of the deposits are of high quality coal, which are rarely found in other provinces.

The Ministry plans to supply 10 million tons of coal a year by 1992 and 30 million tons by 1995.

A special corporation, Huaneng, was set up in 1985 to raise funds for the \$6 billion project to establish the Shenfu-Dongsheng coalfield. It is also responsible for transporting and marketing the coal.

The project also involves building a total of 1,100 kilometres of railway lines, 500 kilometres of highways, a new harbour with an annual loading capacity of 35 million tons, and a 120,000-kilowatt power plant for the coalfield.

Further north from Shenfu-Dongsheng and into the grasslands of Inner Mongolia, thousands of farmer-miners are awaiting the opening of the Jungar coalfield, China's largest opencast coalmine.

Only four per cent of the country's coal output comes from opencast mines. And opencast coal deposits account for a mere seven per cent of all recoverable coal resources.

Jungar, 100 kilometres from Huhhot, capital of the region, has proven coal deposits of 27.2 billion tons in 1,300 square kilometres.

The Ministry expects the first phase of the project to be completed by 1992 with 15-million-tons in annual production capacity.

Total investment is estimated at 4.1 billion yuan (\$872 million).

The basic facilities have all been completed, including highways and water supply.

Another new coalfield, to which experts attach great importance, is the Sino-US joint venture in Pingshuo, Shanxi Province.

Starting production in September 1987, this \$650-million opencast mine has so far produced 20 million tons of coal.

Its output was 12.2 million tons in 1989, making it one of China's 10 leading mines.

"We hope that the three coalfields will be a showcase of the industry," a Ministry official said.

To guarantee a coal supply from the regions, the Ministry is calling for transport to be improved.

Experts say around 350 million tons of coal, or 90 per cent of the coal coming out of the region every year, will come by rail.

They estimate that 56 million tons will go to the three northeastern provinces, 153 million tons to East China and 8 million tons to Sichuan Province.

They say water transportation will carry about 146 million tons of coal, of which 115 million tons will be by sea and 30 million via the Yangtze.

### Local Mines Play a Key Role

40100051B Beijing CHINA DAILY (Business Weekly)  
in English 9 Apr 90 p 4

[Text] Two out of every three tons of extra coal produced in the past decade have come from the country's locally-run mines, Business Weekly has learned.

Experts from the Ministry of Energy Resources firmly believe that these mines—estimated at around 80,000 last year—are playing a decisive role in keeping China's power industry growing.

Locally-run mines include local State-owned mines, township mines, private mines and self-employed miners.

Last year, they produced a total of 560 million tons of coal, up 34 million tons from 1988 and accounting for 54 per cent of China's total output.

In 1978, when the central government began to encourage locally-run mines, only 270 million tons of coal were produced.

But no one can now deny that these mines should keep supplying at least half of the coal produced in China up to the year 2000.

According to the Ministry's plan, they are supposed to produce 700 million tons of coal in the year 2000, equalling the Ministry's target for the State-run mines.

This year they have been told to produce 607 million tons of coal, 47 million tons more than last year.

To enhance the further development of these mines, the Ministry recently decided to investigate 200 coal-producing counties, particularly those mining without licences or proper safety guarantees.

Ninety per cent of locally-run mines are township or private mines, most of which work without licences.

They are engaged in random mining which often results in higher losses and casualties than in State-owned mines.

The Ministry said private mines would be integrated with township mines which have to go through State safety and technology examinations before new licences can be granted to them.

It also said no fresh approvals would be granted to self-employed miners.

"Only in this way can locally-run mines compete with their State counterparts, which are better equipped and financially secure," said a Ministry official.

### Major Mines Will Transform Gujiao

40100051C Beijing CHINA DAILY in English  
12 Apr 90 p 2

[Article by staff reporter Huang Xiang]

[Text] Two major mines which are expected to start operations later this year will make Gujiao, a Shanxi-based mining area, into China's largest coking coal producer, CHINA DAILY has learned.

Malan and Dongqu, each capable of producing 4 million tons of coal a year, will increase Gujiao's capacity to 12.5 million tons a year. The figure will be around 20 per cent of China's annual coking coal consumption.

Coking coal is widely used and has been a badly-needed raw material in metallurgical industry.

The two mines are due to be completed in June and September respectively, according to an official from the Ministry of Energy Resources.

"By then the nationwide need for coking coal may have been met," said the official, who is with the Ministry's General Office.

Situated 50 kilometres west of Taiyuan, capital of the coal-abundant Shanxi Province, Gujiao has proved coal deposits of 4.5 billion tons in a 360-square-kilometre area. Most of the reserves are coking coal.

The Gujiao mining area is under the jurisdiction of the province's Datong Mining Bureau. China's leading mining bureau with 34 million tons in coal output in 1989.

According to the State Planning Commission, which included the project into the central government's Sixth Five-Year Plan period (1981-1986), five mines and coal-washing plants are to be built in Gujiao.

An investment of 3.5 billion yuan (\$744 million), the whole project may take 15 years to complete. [sentence as published]

Part of the project is financed by Japanese government credit, the official said. But he did not specify the exact amount.

## Results, Prospects of Oil and Gas Exploration in Bohai Sea

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DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 10,  
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[Article by Cai Qianzhong [5591 0051 1813] of the Ministry of Geology and Mineral Resources' Marine Geology Institute: "Achievements and Prospects of Oil and Gas Surveys in the Bohai Sea Region"]

[Text] The Bohai Sea region includes Bohai Sea and the coastal continental shelf. It covers a total area of about 200,000 square kilometers and is the primary sedimentation center of Bohai Bay basin. Bohai Sea is surrounded by Liaodong Peninsula, Liao He Plain, North China Plain, and Shandong Peninsula. It is 550 kilometers long from south to north and 346 kilometers wide from east to west. The coastline is 3,700 kilometers long. The marine area includes Bohai Bay, Liaodong Bay, and Laizhou Bay. The average depth is just 18 meters and the total area is about 70,000 square kilometers. Besides oil and gas pools already discovered in Bohai Sea, there are four large oil and gas pools, the North China, Dagang, Shengli, and Lower Liao He, distributed around Bohai Bay. It is China's second largest petroleum industry base at present, second only to Daqing Oil Field. Statistics for 1986 showed yearly crude oil output from the Bohai Sea region at 53 million tons.

### I. Overview of Early Oil and Gas Surveys in the Bohai Sea Region

In February 1955, the Ministry of Geology held the First National Petroleum Survey Work Conference and decided to undertake large-scale petroleum survey work on a national scale in China. In March 1955, five petroleum survey teams were organized and sent to Junggar, Qaidam, Ordos, Sichuan, and North China basins.<sup>1</sup> The North China Petroleum Survey Team established in 1956 began comprehensive geophysical survey work in the North China Plain. With the exception of scattered outcrops of ancient metamorphic rock and Cambrian-Ordovician limestone and basalt at Neihuang in Henan, Longyao in Hebei, and the large and small mountains on the Hebei-Shandong border, most of the plain region is covered by loose Quaternary sediments, so no oil and gas indications were seen. Oil seeps were found only in crystal cavities and fissures in limestone in marginal outcrops around Tangshan. Thus, early petroleum surveys made Paleozoic marine facies sediments the primary target in the search for oil.

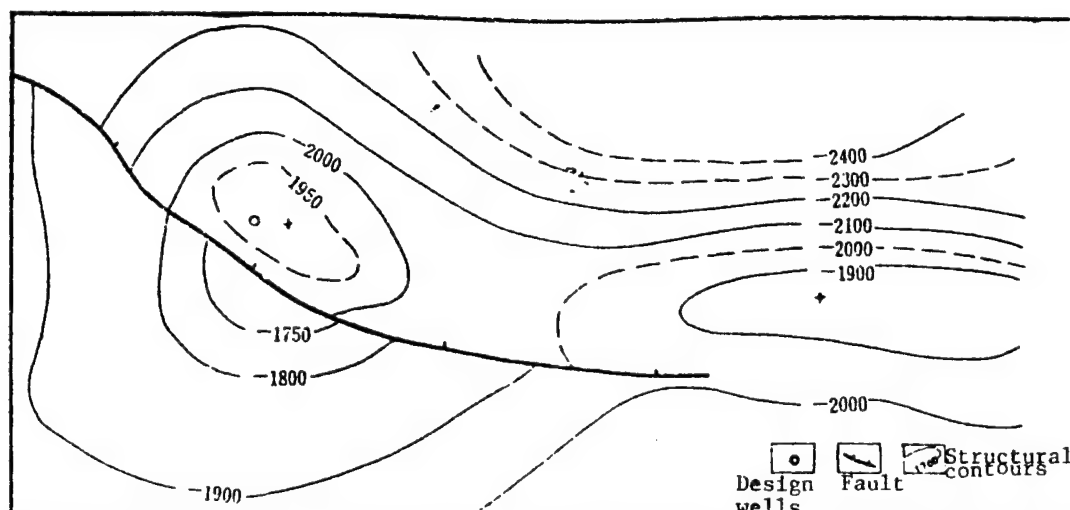
Gravity surveys located Cangxian high gravity zone on the western side of the Bohai Sea region, and the high point at Minghua Town in Nangong County in this zone was chosen as the site for a seismic cross-section. In 1957, the Ministry of Petroleum Industry drilled the first reference well (Hua 1 well) at Minghua Town on the basis of this survey data. Exploratory drilling results

showed the Quaternary Holocene system from the surface down to 120 meters, the Pleistocene system from 120 to 660 meters, the Tertiary Pliocene system from 660 to 1,063 meters, and below this the Ordovician system. No oil and gas indications or oil generating strata systems were seen. After this, the Hua 2 well was drilled at Nanshenggang in Kaifeng County and the Hua 3 well at Fangbazhai in Hebei's Guantao County. Part of the Tertiary system and the end of Cretaceous system red beds were noted in both locations. Thus, it was considered unrealistic to search for Paleozoic oil in the uplift zone. This forced a shift in direction of the main attack from uplifts to depressions, which confirmed that Tertiary sediments were the main target to explore for oil. Subsequently, the survey region moved from west to east to focus on Jiyang and Huanghua depressions in the Bohai Sea region. Seismic exploration also shifted from regional surveys and integrated with sample surveys to locate local structures, which accelerated the pace of the search for oil.

In early 1959, a spot seismic survey by the No 2 Seismic Team of the Zhongyuan [Central Plain] Petroleum Geophysical Exploration Brigade from the Ministry of Geology in the Dongying region of Jiyang depression discovered four trap structures, including Dongying, which provided a foundation for drilling deployments.

In November 1960, the Ministry of Geology held the North China Petroleum Survey and Exploration Conference in Tianjin and turned Dongying structure over to the North China Petroleum Exploration Department of the Ministry of Petroleum Industry as their first choice for exploration. The Hua 8 well drilled on the Dongying structure (Figure 1) found the first oil in North China's Bohai Sea region. This played a pioneering and vanguard role in the discovery of Shengli oil pool. At that time, the Geophysical Exploration Team of Hebei Province's Geology Bureau joined the search for oil and located Yangsanmu structure in spot seismic surveys of Huanghua depression, which laid a foundation for discovering Dagang oil pool.

Before Shengli and Dagang oil pools were discovered, survey work was already gradually extending into marine regions of Bohai Sea. Around 1958, there were reports of oil seeps floating in the sea in Bohai Sea. The Ministry of Geology's North China Petroleum Survey Brigade led the way in joining with the Ministry of Petroleum Industry's Petroleum Exploration Bureau to form the Bohai Sea Oil Seep Survey Group to survey an area extending from Dalian in the north to Fengcai, Zhifu, Yantai, and Weihai, and on to Chengshangjue on Jiaodong Peninsula, Jianjiamiao Archipelago, Changshan Archipelago, Tuoji Island, Chenghuang Island, Hei Island, Daqin Island, Xiaoqin Island, Liugong Island, and so on. Because at the time no oil seeps had been seen in the plain excluding those in Ordovician limestone crystal cavities and fissures at Tangshan in North China, the "oil seeps" seen at sea were hard to believe. There was speculation that they were waste oil discharged from freighters, coastal oil refineries, or shipyards. However,



**Figure 1. Positions of Wells on Dongying Structure**  
(Strata position: strata plotted on map equivalent to  $T_2$  reflection layer)

detailed surveys and visits and collection of a large amount of oil for chemical testing and analytical comparisons showed clearly that the floating oil seeps were real. The conclusion was that these oil seeps came from Bohai Bay "itself." It was conjectured that the oil seeps were unrelated to Paleozoic strata but were closely related to Mesozoic and Cenozoic strata formed after the Jurassic and may have migrated to the sea surface along faults. This led to much speculation about whether or not there was petroleum in Bohai Sea.

In 1959, the Ministry of Geology decided to do an aeromagnetic survey of Bohai Sea and established the Sixth Geophysical Exploration Brigade in 1960 to do a gravitational area survey and seismic reflection large cross-section survey of the sea floor in Bohai Sea. A preliminary demarcation was made of a depression covering about 30,000 square kilometers. It also determined that Tertiary sediments were as much as 9,000 meters thick. The surveys found two structural zones and showed that the connection between Bohai Sea and the continent was Bohai Bay basin. This expanded the scope of surveys of the petroliferous region and raised confidence that oil would be found. In 1955, while doing a petroleum survey in Songliao Basin, Ministry of Geology survey teams also moved south to Lower Liao He Plain. First, the Second Geophysical Exploration Brigade did a comprehensive geophysical survey which demarcated Lower Liao He depression and delineated primary structural components, depressions, and uplifts. It located local structures and confirmed that Lower Liao He depression was also part of Bohai Bay basin.

During the early stages of surveys in the Bohai Sea region, the Ministry of Geology and Ministry of Petroleum Industry joined together in cooperation and made significant contributions to creating China's second large oil and gas province and petroleum industry base area.

## II. Main Results of Oil and Gas Surveys

The period from 1955 to 1965 was the early oil and gas survey stage in the Bohai Sea region. Outstanding achievements were made in relying on our own efforts by using all forms of integration methods over this 10-year period. Overall, there were six major achievements:

1. Delineation of the basin, demarcation of regional structures, and establishment of a stratigraphic sequence were the most important basic achievements of early oil and gas survey work in Bohai Sea.

Before oil and gas surveys were done in the North China Plain, many Chinese geologists had offered all types of conjectures about geological conditions beneath the plain. However, their concepts of the basin's properties, including its formational period and structure, were not very clear. Renowned geologist Li Chunyu [2621 2504 2509] offered this view in 1951: "For the strata under this plain, both the Cambrian and Ordovician are marine facies, the Carboniferous and Permian strata are part continental facies with some interbedded marine facies, and all may have produced oil."<sup>2</sup> This sort of deduction that the formational period of North China Basin was restricted to the post-Cretaceous and pre-Eocene periods failed to recognize that this basin's primary formational period was the Cenozoic, after the late Yanshan period.

Initial surveys of a basin covered by loose Quaternary sediments over a large area (including being covered by seawater) relied mainly on comprehensive geophysical exploration of a large area. This is particularly true of integrating gravitational, magnetic, and electrical methods, which quickly determined the scope of the basin and confirmed that the North China Plain was a large sedimentary basin. It rises from Yan Shan in the north and extends south to Dabie Shan and west to

Taixing Shan, connecting with Tanlu fracture to the east, delineating a basin with a total area of 400,000 square kilometers. It demarcated structural elements including nine depressions: Jiyang, Hanghua, Boye (later renamed Jizhong [central Hebei]), Linqing, Lower Liao He, Bozhong, Kaifeng, Zhoukou, and Hefei; and five uplifts: Wudi, Cangxian, Neihuang, Tongxu, and Xixian. The depressions covered a total area of 220,000 square kilometers.

During the early surveys, several medium-depth wells and parameter wells drilled to match up with geophysical exploration data for description systematically revealed strata beneath the plain. The survey teams used a large amount of drilling data to divide groups of members in the Tertiary strata profile into A, B, C, and D groups moving from top to bottom. They also did a unified regional comparison of strata in Jiyang and Huanghua depressions. Next, they continued to collect strata information, particularly deep strata revealed by exploratory drilling, to perfect the profile. They then used a unified comprehensive strata sequence for Tertiary strata established by the Ministry of Petroleum Industry. Moving from the top downward, the upper Tertiary is divided into the Minhuazhen group and Guantao group, while the lower Tertiary is divided into the Dongying group, Shahejie group, and Kongdian group. Drilling confirmed the results: the upper Cretaceous and Paleocene are missing from the Bohai Sea region. This is closely related to late Mesozoic and early Cenozoic mantle uplifting centered on the central uplift in Bohai Sea. The Triassic is absent throughout the sea region and the middle and lower Jurassic are absent in most of the region, while 1,000 to 4,000 meters of upper Jurassic to lower Cretaceous volcanic clastic rock remain in some local areas. Tanlu fracturing activity controlled late Cretaceous sedimentation, and upper Cretaceous Wangshi group red beds are widely distributed to the east of the fracture. At the time, strata sequence determinations depended mainly on lithology, microfossils, and electrical logging for delineation and comparison. The feeling was that all the strata were continental facies sediments. After application of ultramicroscopic fossil identification technologies in the 1980's, Ministry of Petroleum Industry exploration research departments found calcareous ultramicroscopic fossils and marine facies fish, algae, Foraminifera, and so on in the early Tertiary Shahejie group in Bohai Bay basin. Only then was it confirmed that the basin had not undergone marine intrusion from the Eocene to the end of the Oligocene. Practice has proven that after a basin is encircled, delineation of local structures and establishment of a stratigraphic sequence is especially important for evaluating basin geology in the early stages of a survey.

2. Preliminary determination of sedimentary facies in the basin and discovery of oil-generating rock systems showed that breakthrough progress had been made in survey work.

In June 1960, Shandong's survey team found the first set of interbedded grayish-green fine sandstone, arenaceous

mudstone, and granular sandstone at a depth of 704 to 1,018 meters at Boxing 1 well. These were interbedded with many strata of highly fossiliferous marlite and black papyry shale assumed to be from the Oligocene. It was named the "Jiyang group." Subsequently, exploration departments also found a group of grayish-green mudstone with a lithology basically identical to that at Boxing 1 well while drilling at a depth of 1,211 to 1,916 meters at Shahejie Hua 7 well at Shang He. The revealed cross-section was more complete, however. They were deep lacustrine and semi-deep lacustrine facies sediments, and were named the "Shahejie group." They were considered to be an oil-generating rock system. This confirmed that Jiyang depression was an oil-generating depression and provided a better understanding of oil sources. At the time, this discovery was considered to be a most encouraging achievement.

Work by exploration departments in Dongying depression showed that the lower Tertiary was over 7,000 meters thick and that the Shahejie group's third member was the main oil-generating strata. As much as 1,000 to 1,900 meters thick, it contained high concentrations of organic matter (organic carbon 1 to 2.5 percent, bitumen "A" 0.5 to 0.4 percent with a maximum of 0.7 percent) and a hydrocarbon content of 700 to 1,400 ppm.

By obtaining these results, the Ministry of Geology was able to make a joint policy decision with the Ministry of Petroleum Industry at the historically significant North China Petroleum Survey and Exploration Conference held in Tianjin which made Jiyang and Huanghua depressions the first choices as the focus of the best oil and gas prospects and specified six key attack points at Matouying, Beitang, Yangsanmu, Yanshan, Yihehuang, and Dongying around Bohai Bay. This speeded up the search for oil and concentrated forces for an oil and gas breakthrough.<sup>3</sup>

3. Successful exploratory drilling in the Dongying structure established the first milepost in the early search for oil in North China's Bohai Sea region.

Although discovery of the Shahejie group oil-generating rock system might have confirmed the existence of an oil and gas generation process in the basin, it was not the same as finding oil and gas pools of industrial value. The most urgent task at the time was to locate trap structures for deploying exploratory drilling and ideal generating, reservoiring, and capping combinations. Thus, the survey reduced its "scope" and moved from Jiyang depression to concentrate on Dongying depression, which had favorable oil-generating conditions. The main goal of seismic surveys also shifted to finding "uplifts within depressions" secondary structural zones. After finding indications of an anticline at Dongying, they quickly increased the density of their measurement net and began a sample survey. Eventually, they found the Dongying, Shenglicun, Tuozhuang, and Yihezhuang local structures in the Dongying region and selected the Dongying structure, which had the most reliable degree of entrapment, to drill the Hua 8 well. This well found



oil-bearing sandstone in the lower Tertiary Dongying group. Given the urgent need to find oil, they stopped drilling the well before it was finished and obtained a daily output of more than 10 tons of crude oil. This was a breakthrough in oil exploration in North China's Bohai Sea region, a historic achievement which fully confirmed that the Tertiary in the Bohai Sea region was rich in petroleum. Next, exploration departments drilled the Ying 2 well in Dongying structure. There was a powerful blowout when they drilled into the third member of the Shahejie group which erupted with a daily output of up to 550 tons of crude oil, making it the first well with a high output oil flow in the Bohai Sea region. In 1965, exploration departments also drilled a deep exploratory well (Tuo 11 well) in Shenglicun structure with results that became famous as soon as they started drilling. They drilled China's first 1,000-ton well and brought Shengli Oil Field, the first big oil field in North China's Bohai Sea region, into existence.

Every significant achievement brought a leap in the guiding ideology in the search for oil and raised practice and experience to the level of theory. Discovery of Shengli oil pool provided convincing proof that continental facies sedimentary basins also could have the geological conditions for large oil pools, but not all conditions were the same as those in marine facies sedimentary basins. For example, lithologic variations in continental facies strata are more complex and the distance of oil and gas migration is often restricted by lithology which prevents long-distance migration. Both Dongying and Shenglicun petroliferous structures were located quite near Dongying oil-generating depression and had excellent conditions for rich accumulation of oil and gas. This is a common property of continental facies oil and gas movement.

4. Industrial oil flows from Yangsanmu structure in Huanghua depression opened another new oil exploration base area in the Bohai Sea region and laid a foundation for discovering Dagang oil pool.

In December 1958, while reporting on Yangsanmu and Kongdian gravitational data to Soviet expert (Pan-qieliefu), senior engineer Guan Shicong [7070 1102 5115] and I speculated that it was a Paleozoic uplift. A subsequent seismic sample survey confirmed that the Yangsanmu gravity high was a Cenozoic trap structure.

In 1960, I accompanied senior engineer Guan Shicong to inspect geological conditions in North China and throughout the Bohai Sea region. We did a more systematic study of gravitational and seismic survey data and drew the preliminary conclusion that "1:100,000 gravitational measurements show that the northern part of Huanghua depression east of Tianjin is interconnected to Bohai Sea depression. It is a deep and large depression region running parallel to the almost east-west strike of the mountainous region in east Hebei, repeating two regional negative anomaly zones and one positive anomaly zone. In the negative anomaly zones, quite a few positive anomaly zones appear in the gravitational

secondary derivatives. This should receive attention and we should quickly undertake seismic survey and sample survey work." "On the southern slope of Huanghua depression, besides confirming that Yangsanmu is a structure by seismic sample surveys, we discovered several seismic uplifts including Koucun, Huanghua, Luqiao, Dabai Caozhong, Yangerzhuang Qiansha Hutong, and others in the seismic profile measurements. Additional sample survey work is needed for confirmation, but these seismic uplifts are interesting since they conform exactly to the gravitational secondary derivative positive anomalies and residual gravitational anomalies. They may be similar to Jiyang depression with structures forming a secondary structural zone with a nearly east-west strike. It is a favorable region for oil exploration."<sup>1)</sup>

During the oil and gas survey of Huanghua depression, I stayed at Yangsanmu and saw clearly that the oil and gas survey at Huanghua depression showed prominent success in the first drilling in Yangsanmu structure.

The Huang 1 well, where drilling was completed on 15 August 1961, obtained a logging oil flow in the lower Tertiary Jiyang group, which gave us a profound understanding that the scope of the oil-bearing area could be expanded 200 kilometers north from the Dongying region. Drilling of the Huang 3 well was completed on 11 September 1962 and logging produced a gusher with daily crude oil output of more than 30 tons. This confirmed deductions from our notes while traveling in north China that Huanghua depression and Jiyang depression were favorable regions for finding oil. The important achievement in finding oil in Yangsanmu structure laid a foundation for finding Dagang oil pool, but even more importantly, it greatly expanded the scope of oil exploration in the Bohai Sea region. Breakthroughs in the Dongying, Shenglicun, and Yangsanmu structures deepened our understanding of oil and gas regularities in the Bohai Sea region and focused our sights on surging Bohai Sea. It also brought Daqing's exploration teams into the area and opened a major battle for petroleum in north China.

5. Finding oil in Fengheying structure opened a new survey region in central Hebei.

The geographic location of Jizhong [central Hebei] depression does not place it in the Bohai Sea region, but the formational period of the basin and its sedimentary systems, structural characteristics, and other properties make it part of Bohai Bay basin. After finding oil in Yangsanmu structure, survey teams expanded on their achievements by spreading out through the region. They did complete studies of comprehensive geophysical exploration data for Jizhong depression and combined this with successful experiences in finding oil at Jiyang and Huanghua to select the Fengheying gravity high at the northern tip of Jizhong depression for a seismic survey to find structural traps. They drilled the Jing 1 parameter well on the structural high point and obtained an intermittent gusher oil flow in the lower Tertiary.



This achievement showed that Bohai Bay basin undoubtedly was a large petroliferous basin and its scope could be expanded to include all of Jizhong depression. The survey teams then decided to do a regional electric and seismic cross-section of Jizhong and combined this with parameter wells for confirmation and description to clarify the structural characteristics and petroliferous properties of the basin on a regional basis.

On 9 March 1963, the Ji 1 parameter well was drilled at Lingang in Lixian County to coordinate with the large cross-section. Petroliferous sandstone was encountered when drilling into deep parts of the lower Tertiary, confirming that Jizhong depression also had excellent prospects for oil and gas exploration.

What deserved attention, however, was that after drilling the Jing 1 parameter well in Fengheying structure, no oil was found in any of several wells drilled by exploration departments in the surrounding area. The understanding was that the structure was composed of complex fault blocks and that the oil-gas-water combination was strictly controlled by fault blocks. This fact told us that we must rapidly improve geophysical exploration techniques if we wanted to increase our success rate in searching for oil because it is extremely hard to clarify fault block structures using only seismic techniques at scattered points.

6. A new realm for natural gas surveys was opened in Lower Liao He depression.

Regional survey tasks for Lower Liao He depression were basically completed between 1955 and 1964, and 13 structures including Rehetai were found. The Liao 1 well drilled in Huangjindai structure encountered petroliferous sandstone in the lower Tertiary. This also confirmed that this depression was part of the Bohai Bay basin sedimentary system. The entire 10-year period clarified the scope and corridors of Bohai Bay basin. At the time, however, output from Shengli, Dagang, and other oil pools was mainly industrial oil flows. No high-output natural gas was seen. After moving into Lower Liao He, the North China Survey Team used the original surveys as a basis for focusing on deep exploratory drilling in Tianzhuangtai and Panshan depressions. They drilled 12 wells, including 10 which found petroliferous sandstone and six in which logging results showed oil and gas flows. The best was a daily output of 650,000 cubic meters of natural gas from the lower Tertiary at the Liao 6 well on Rehetai structure. This was the first high output of natural gas obtained in Bohai Bay basin, and practice showed similarities in the organic evolution of continental facies sedimentary basins in east China compared to certain marine facies sedimentary basins, and similarly, that abundant petroleum and natural gas resources might be found. The survey results reinforced theories of oil formation in China's continental facies basins and completely eliminated the wholly unscientific argument that China's Tertiary continental facies sediments did not generate oil and gas.

The initial victory at Lower Liao He attracted a large army which developed exploratory drilling. Their work over 10 years proved four oil and gas pools at Xinglongtai, Rehetai, Huangjindai, and Dujiatai and afterwards proved Shenyang oil pool.

### III. New Advances, Prospects for Exploration and Development

From the time the first discovery well was drilled in the Bohai Sea region up to now, 30 years were spent in developing surveys and exploration, and rich achievements were made in theory and practice. These glorious achievements were entered into the annals of world oil and gas exploration.

First, in regard to theory, summarization of a large amount of exploration practice over many years showed that Bohai Bay basin is a multicomponent petroliferous basin composed of many fault-subsidences, many fault blocks, many oil-bearing strata systems, and various categories of oil and gas reservoirs. The geodesic background is an accretionary continental margin with a basement composed of ancient blocks. It is a rift valley-type extension fault-subsidence basin formed by several instances of structural movements since the late Yanshan period. The sedimentary system is mainly continental facies Tertiary with interbedded temporary marine intrusion sediments. The sedimentary environment was mainly large lake basin deep lacustrine facies, semi-deep lacustrine facies, and fluvial facies. The primary oil generation period was the early Tertiary. The generation, reservoiring, and capping combination was formed of very thick sandy mudstone and locally interbedded gypsum-halite [gaoyan (5221 7770), a type of evaporite] strata on a foundation of long-term subsidence. Oil and gas accumulations generally conform to a specific structural fracturing zone and do not involve a single strata system or single oil and gas reservoir category and specific oil-water relationship. Usually, there are often groups of composite-type oil and gas pools with several oil-bearing strata systems, multiple oil-water systems, and many types of oil and gas reservoirs overlapping each other vertically and horizontally to form different oil-bearing strata systems linked together in rich oil and gas accumulation zones which are also restricted by fault blocks. They can be called special Chinese-type continental facies oil and gas pools.<sup>4</sup>

Over 50 oil and gas pools have been found in Shengli Oil Field, which is located on the Huang He delta, and over 30 have now been developed. Yearly crude oil output reached 31.6 million tons in 1987 and total production is 272 million tons of crude oil and over 153.70 million cubic meters of natural gas.

In 1986, Gudong oil pool with a daily output of over 10,000 tons of crude oil was built on the beach where the Huang He enters the sea. This was the 49th oil pool discovered in more than 20 years of battle after Shengli oil pool and it was the biggest draped-structure oil pool

discovered in China in the nearly 10 years after the Renqiu ancient buried hill oil pool was found in north China.

In 1988, a continuous oil-bearing area was found in the empty region between Chengdong oil pool, Zhuangxi oil pool, and Bonan oil pool in the delta zone between the new and old entrances of Huang He to the sea known as the "golden triangle." The Bohai 1 deep exploratory well discovered Paleozoic industrial coal-formed gas flows at 4,696 to 4,700 meters with daily gas output of 36,009 to 57,615 cubic meters.

The big Cheng Island oil pool recently discovered offshore from the northern bank of the Huang He mouth is located 6.5 kilometers north of the Huang He mouth and just 5 kilometers from the nearest point on the shore. The water is 3 to 10 meters deep and the structure covers an area of 82 square kilometers. Pure oil strata 108.8 meters, 81.2 meters, and 46.5 meters thick, respectively, were found at Chengbei 11, 12, and 20 exploratory wells in the Mesozoic and lower Tertiary Dongying group and upper Tertiary Guangtao group and Minghuazhen group. The Chengbei 12 and 20 wells have already produced tests of 184 and 144.6 tons of daily crude oil output. They now control an oil-bearing area of 34 square kilometers with geological reserves of 120 million tons. This indicates a major breakthrough in petroleum exploration in shallow offshore regions of China and a decision has been made to build an artificial island to develop these new oil pools.

In 1980, the Bohai Sea Petroleum Company and foreign petroleum companies began cooperating to explore and develop Bohai Sea oil pools. Together they completed 70,000 kilometers of marine seismic testing lines, discovered 14 oil-bearing structures, and drilled 108 offshore wells (through 1987). Chengbei oil pool jointly developed by China and Japan is 88 kilometers offshore southeast of Tanggu. Two production platforms, each linked to several oil wells, can produce over 400,000 tons of crude oil annually.

Major advances also were made in oil and gas exploration in Liaodong Bay managed independently by Bohai Sea Petroleum Company. Two large oil reservoiring structures were discovered at Jinzhou and Suizhong. The first exploratory drilling well drilled in Suizhong 36-1 structure, the 36-1-1 well, produced a daily output of 190,000 cubic meters of natural gas from the lower Tertiary Dongying group and daily output of 142 cubic meters of crude oil from the Paleozoic weathered crust. This structure covers an area of 130 square kilometers. It is 60 kilometers from Suizhong County and the water is 30 meters deep. Suizhong 36-1-2 well located 11 kilometers from this well was drilled into lower Tertiary Dongying group oil-bearing strata 163 meters thick which produced a test daily output of 200 tons of crude oil at a one-half jet opening.

From the Jinzhou 20-2 structure between the large Liaoxi and Liaozhong [west Liaoning and central Liaoning] depressions to the Luda 19-2 structure at the southern tip, there is a 250-kilometer-long petroliferous structure zone. The lower Tertiary is buried at a depth of almost 10,000 meters and has extremely rich oil sources. The Jinzhou 20-2 condensate oil and gas pool is located 50 kilometers southeast of Jinxi County in Liaoning Province in water 25 to 30 meters deep. It was discovered in November 1984. The Jinzhou 20-2-10 well encountered high output oil and gas flows in lower Tertiary Shahejie group continental facies limestone and sandstone which tested out to an equivalent of 646 cubic meters of daily crude oil output and 93,750 cubic meters of natural gas. Nine preliminary exploration wells and evaluation wells have been drilled since then (through 1987) and oil was seen in eight of them. Most were high output wells.

Preliminary statistics indicate that initial proven petroleum geological reserves in Suizhong 36-1 oil pool exceed 140 million tons, equivalent to five Chengbei oil pools. This shows that China's self-managed offshore petroleum exploration technologies have entered a new level.

The Bohai Sea Petroleum Company puts an oil field into operation almost every year. Projections are that around 1990, Bohai Sea oil pools will form an annual production capacity of more than 1 million tons of crude oil and 500 million cubic meters of natural gas. In 1988, additional oil-bearing strata nearly 60 meters thick were discovered in the lower part of Suizhong 36-1 oil pool, and new oil and gas structures discovered in the northern part of Jinzhou 20-2 oil and gas pool have an oil-bearing area of 30 square kilometers.

Over 1,000 kilometers of two-dimensional seismic survey lines have been completed in the new Sino-Japanese cooperation region in Bohai Sea's Laizhou Bay and a regional geological evaluation in the Sino-American cooperation region in central Bohai Sea has been completed. China Petroleum and Natural Gas Corporation forecasts suggest that petroleum reserves in the Bohai Bay region may be as large as 3 billion tons. Minister Wang Tao [3769 3447] in the former Ministry of Petroleum Industry said: "Shengli oil pool has now prepared the resource conditions to build a second Daqing Oil Field." Planned yearly crude oil output may reach 50 million tons by 1990. The rapid advances in exploratory drilling for oil and gas in the Bohai Sea region are just unfolding.

The Bohai Sea region has very broad future prospects for oil and gas exploration and significant potential oil and gas resources. Like Venezuela's Lake Maracaibo Oil Field, there is substantial potential both in basin area and degree of exploration. Almost 70 years have passed since the first barrel of petroleum was extracted from Lake Maracaibo in 1917. The lake covers an area of over 14,000 square kilometers, just one-fifth the size of Bohai Sea, but more than 16,000 oil wells have been developed. Oil transport pipelines 10,000 kilometers long and gas

transmission pipelines 40,000 kilometers long have been installed on the lake bottom, so the extent of exploration and oil field construction far surpass those in the Bohai Sea region. Statistics through 1987 show that only 108 offshore wells have been drilled in Bohai Sea, an extremely low degree of exploration, so there are substantial petroleum geological reserves which remain undiscovered.

There are many new realms in the area of exploration that we can still exploit and discover. From the perspective of regional analysis, if large gas pools were discovered in Lower Liao He, Liaodong Bay, and Zhongyuan oil pool at the southern tip of the basin, why were none found in Shengli oil pool in the central part of Bohai Bay basin? This is an important geological topic which deserves study. First, we should summarize and rethink our usual oil pool exploration methods and revise technical methods to establish a natural gas exploration team. I believe we can make major advances. In addition, analysis using geologic body theories shows that Shengli oil pool is located on a Paleozoic basement, which is an ancient continental margin. Its southern boundary is in collision contact with the Ludong [east Shandong] geologic body, which is favorable for oil and gas accumulation. This is a new realm which deserves exploration for coal-formed gas.

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#### Results of Hydrocarbon Exploration in Tarim Basin

906B0035B Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 10 No 3, Sep 89 pp 276-282; manuscript received 6 Jan 89

[Article by Kang Yuzhu [1660 3768 2691] of the Northwest Petroleum Geology Bureau in the Ministry of Geology and Mineral Resources: "Tremendous Achievements in Oil and Gas Exploration in Tarim Basin"]

[Text] Since the Northwest Petroleum Geology Bureau was established in the Ministry of Geology and Mineral

Resources in 1988, correct leadership by the Ministry of Geology and Mineral Resources and Xinjiang Uygur Autonomous Region and staunch fighting by all bureau employees brought China's first major breakthrough in Paleozoic marine facies oil and gas pools at Xa 2 parameter well on Xayar uplift's Yakla structure in north Tarim Basin on 22 September 1984. The Ministry of Geology and Mineral Resources organized several regional bureaus to go to north Tarim in 1985 for joint exploration work on an unprecedented scale. High output oil and gas flows were again obtained from the Cambrian system at Xa 7 and Xa 4 wells in 1986, giving preliminary indications that Yakla is an oil and gas pool with a definite scale. After July 1988, high output oil and gas flows were also obtained from the Jurassic at Xa 4 and Xa 7 wells, from the lower Cretaceous at Xa 5 well, and from the Ordovician at Xa 14 well on Akkol structure, achieving major breakthroughs in new regions, new structures, new strata, and new categories (abbreviated below as the "four new areas"). This pushed oil and gas exploration and surveys in north Tarim into a new development stage of a focus on areas and on reserves. Reviewing history, summarizing experiences, continuing to move forward, and opening up advances will make new contributions to finding larger and more oil and gas pools.

#### I. Primary Geological Achievements and Oil-Bearing Prospects

##### A. Oil and Gas Achievements and Their Significance

1. Mar 1 parameter well on Markit slope extracted its first oil-bearing rock core from Carboniferous limestone at a depth of more than 4,100 meters in 1980. Crude oil leaked from the core after it was removed from its casing. This confirmed that oil and gas were generated and reseroured in the Carboniferous and that fractures in carbonate rock played a role in controlling the oil.
2. Xa 2 parameter well obtained high output oil and gas flows from Ordovician dolomite at a depth of 5,391 meters in Yakla structure on Xayar uplift on 22 September 1984. It produced about 1,000 cubic meters of crude oil and about 2 million cubic meters of natural gas daily.
3. In 1986, logging of Cambrian dolomite at a depth of over 5,400 meters at Xa 7 well on Yakla structure produced a daily output of 69 cubic meters of crude oil and 138,900 cubic meters of natural gas in 1986. Logging of Cambrian dolomite at a depth of over 5,400 meters at Xa 4 well produced a daily output of 13 cubic meters of crude oil and 120,000 cubic meters of natural gas. This confirmed that Yakla structure was an oil and gas pool with a definite scale.
4. Xa 14 well on Akkol structure logged Carboniferous limestone at a depth of 5,380.10 meters on 31 July 1988 and produced a daily output of 190 cubic meters of crude oil and 10,000 cubic meters of natural gas. Testing of Jurassic sandstone at a depth of 5,367 to 5,371 meters at Xa 7 well on 27 August produced a daily output of 100

cubic meters of crude oil and 50,000 cubic meters of natural gas. Logging of Jurassic sandstone at a depth of 5,375 to 5,380 meters at Xa 4 well on Yakla structure on 17 September produced a daily output of 153.6 cubic meters of crude oil and 265,400 cubic meters of natural gas. Logging of lower Cretaceous sandstone at a depth of 5,324 to 5,328 meters at Xa 5 well on Yakla structure on 11 November produced a high output, with daily output of 500 cubic meters of crude oil and 3.2 million cubic meters of natural gas.

The Ministry of Geology and Mineral Resources has drilled 13 deep wells on Xayar uplift (which covers an area of about 30,000 square kilometers), and every well had excellent indications of oil and gas. Small oil and gas flows were seen at six wells (also during logging) and five wells produced high output oil and gas flows. This successful exploration hit rate is seldom seen in China or in foreign countries.

The Ministry of Geology and Mineral Resources and China Petroleum Corporation have now obtained high output oil and gas flows from four structures: Yakla, Akkum, Akkol, and Yingmaili. Small amounts of oil and gas were also obtained from four more structures (now in the logging process). The oil-producing strata are the upper Sinian, Cambrian, Ordovician, Triassic, and lower Cretaceous. This proves that north Tarim Basin has a multi-era oil generation combination.

These breakthroughs have attracted enormous attention in China and foreign countries. After listening to a report on the gusher at Xa 2 parameter well, State Council Vice Premier Wan Li said: What the Chinese people have accomplished by themselves is quite extraordinary and it is a great contribution. State Council member Kang Shi'en [1660 0013 1869] said: High output oil and gas flows from Xa 1 parameter well are a big breakthrough. Many foreign newspapers also reported the big oil and gas output at Xa 2 parameter well.

Subsequent major breakthroughs have been made in north Tarim Basin since July 1988. Party and state leaders again expressed their appreciation and encouragement after learning of them. Attention from all areas is the reason that breakthroughs in north Tarim Basin have such great strategic significance.

1. Vast northwest China and the coastal continental shelf are the main replacement regions for China's oil and gas resources. The important breakthrough with Paleozoic marine facies oil and gas pools in north Tarim Basin has solidified people's confidence in the oil and gas prospects of Tarim Basin and clarified goals. Estimated oil and gas reserves in Tarim Basin have risen from the original 3 billion-plus tons to 12 to 15 billion tons. This compelled the state to make a strategic decision about large-scale exploration and development of Tarim petroleum at an early date.

2. People have doubted the oil and gas prospects of the lower Paleozoic in Tarim Basin and they received widespread attention after finding oil at Xa 2 parameter well.

For this reason, this breakthrough is an important achievement for China's progress toward the "four new things" in its second round of petroleum surveys, and it is an effective advance for exploration and development of Paleozoic marine facies oil and gas pools and for petroleum geology theory in China. It has opened a new chapter in the development of China's petroleum industry.

3. Breakthroughs in north Tarim are a turning point in the search for oil in Tarim Basin. Since the nation was founded, oil and gas survey and exploration work in Tarim Basin has been targeted at Mesozoic strata, and there have been many ups and downs. After Xa 2 parameter well produced oil, a shift began toward the Paleozoic, particularly in deployment of exploration work in the lower Paleozoic as the primary oil and gas source rock and the achievements that were made. This greatly accelerated the pace of exploration and showed that Tarim Basin is the best area in China for finding Paleozoic marine facies oil and gas pools.

A corridor of large oil and gas pools has now been revealed clearly in the rich oil and gas accumulation zone of Xayar uplift in north Tarim Basin and large oil and gas pools will soon be the focus there.

## B. Geology Achievements, Oil and Gas Prospects

### 1. Paleozoic Strata and Petroliferous Properties

#### a. Sedimentary Development

Tarim Basin underwent two episodes of marine intrusion—marine regression sedimentation cycles during the Sinian to Devonian and Carboniferous to Permian periods.

**Sinian:** The best development was at Kuruktag, Manji-aer, Kalpin, and other areas. The lower Sinian is clastic rock and drift rock interbedded with acidic volcanic rock that contacts with pre-Sinian metamorphic rock below it at an unconformable angle. The upper Sinian is mainly littoral and neritic carbonate rock and clastic rock. The total thickness is 910 to 7,500 meters.

**Cambrian and Ordovician:** Sediments from this period are widely distributed and complete with the exception of the fault-platform region in the southeast. They are mainly neritic facies carbonate rock interbedded with clastic rock. The bottom part of the Cambrian is interbedded with siliceous phosphatic rock. The total thickness is 1,000 to 4,000 meters. It tends to become thinner moving from the northeast to the southwest of the basin.

**Silurian and Devonian:** These systems are absent in the southeast fault-platform region and part of north Tarim Basin. Their range is obviously smaller than that of the Cambrian and Ordovician systems. The Silurian is littoral-neritic marine facies green sandstone interbedded with marl and shale from a marine regression environment. The Devonian is continental facies red clastic rock

which contacts the Carboniferous capping it above at an unconformable angle. The total thickness is 900 to 3,000 meters.

**Carboniferous and Permian:** These are found throughout the area with the exception of the southeast fault-platform region and the northern part of Xayar uplift. The Carboniferous is mainly necritic carbonate rock interbedded with pelitic rock. The lower Permian in the western part of Tarim Basin is alternating marine and continental facies carbonate rock and clastic rock. It is continental facies carbonate rock in the eastern part, and is interbedded with volcanic eruptive rock at Bachu and part of north Tarim Basin. The upper Permian is continental facies red clastic rock which has an unconformable angle with the Mesozoic capping it above. The total thickness is 2,000 to 4,500 meters and it is thicker in the southwest and thinner in the northeast.

#### b. Petroliferous Properties

There are extremely abundant oil and gas indications in the Paleozoic in Tarim Basin. They are characterized by multiple periods, multiple strata positions, multiple regions, and multiple categories. They have been discovered in the upper Sinian, Cambrian, Ordovician, Silurian, Devonian, Carboniferous, and Permian systems, indicating broad prospects for finding oil and gas in the Paleozoic at Tarim.

In its 1969 report "Petroleum Geology Characteristics and Directions for Oil Exploration in Tarim Basin," the Comprehensive Geology Brigade in the Ministry of Geology suggested that lower Paleozoic Cambrian and Ordovician carbonate rock was an important oil generating and reservoiring rock system, so it should be the focus of attention. They also felt that Xayar uplift was a favorable region to explore for Paleozoic oil and gas pools. After the breakthrough at Xa 2 parameter well, I used regional geological analysis along with analysis and appraisal of crude oil from this well by the Central Petroleum Geology Laboratory in the Ministry of Geology and Mineral Resources as a basis for pointing out in December 1984 that the primary oil source strata for the crude oil from this well as the Cambrian and Ordovician systems. Beginning in 1985, special research work was carried out for the sedimentary facies and oil generating and reservoiring properties of the lower Paleozoic in north Tarim Basin. The conclusion was that Cambrian and Ordovician, upper Sinian, and lower Silurian micritic limestone, algal veined dolomite, muddy shale, and other types of rock could generate oil. The organic carbon content of the limestone was generally 0.08 to 0.78 percent, with a maximum of 12.28 percent. It was 0.05 to 1.78 percent in the muddy shale. The bitumen A was 575 to 1,475 ppm and the hydrocarbon was 109.5 to 841.6 ppm. Bitumen reflectivity  $R_o$  was 1.0 to 1.7 percent, placing it in the mature to highly mature stage. The thickness of the oil generating rock was 500 to 2,000 meters.

The Carboniferous and Permian oil generating rock is dark muddy shale and limestone. The limestone has an organic carbon content of 0.07 to 0.32 percent and a bitumen A content of 0.06 percent. The mudstone has an organic carbon content of 0.86 to 1.2 percent and a bitumen A content of 0.04 to 0.14 percent. Bitumen reflectivity  $R_o$  was 0.8 to 1.4 percent, placing it in the mature to highly mature stage. The thickness of the oil generating rock was 200 to 800 meters, with a maximum thickness of about 1,300 meters.

Preliminary calculations of Paleozoic oil and gas resources in Tarim Basin as a whole are 1 to 1.2 billion tons.

Comprehensive analysis of sediment distributions, oil and gas generation and reservoiring conditions, structural characteristics, depth of burial, and other characteristics indicates that Xayar uplift, the central uplift region, the Beiminfeng-Luobuzhuang fault-uplift, Markit slope, Konqi He slope, and other areas are favorable regions for rich accumulations of Paleozoic oil and gas.

#### 2. Xayar Uplift Is an Area for Finding Large Oil and Gas Pools

##### a. Abundant Oil Sources

The Paleozoic is rather completely developed on Xayar uplift, being distributed throughout except where absent in partial areas of Luntai fault-uplift and Korla nose-uplift. Existing data would seem to indicate thicknesses of 300 to 700 meters for the Carboniferous and Permian systems, 100 to 800 meters for the Silurian and Devonian systems, 800 to 2,000 meters for the Cambrian and Ordovician systems, 500 to 1,000 meters for the Sinian system, and 4,000 to 5,400 meters for the middle Cenozoic. Paleozoic oil generating rock is extremely well-developed on Xayar uplift, with a total thickness of 300 to 1,300 meters. The geochemical indices and maturity of organic matter in the oil generating rock are close to those in north Tarim Basin outlined above.

Moreover, Xayar uplift is located between three oil generating depressions, Kuqa depression to the north, Awat fault-subsidence to the west, and Manjiaer-Shuntuoguole depression to the south, so there are extremely abundant oil sources.

##### b. Superior Structural Conditions

Xayar uplift is a paleo-anticline with an almost east-west strike. The central part of the anticline is in the Xinhe-Luntai area and is composed of pre-Cambrian phyllite. Systems in sequence from the Cambrian to Permian are found on its southern flank. Its northern flank has been dismembered by long-term activity of Yakennan fracture, so the Paleozoic is incompletely developed in Kuqa depression.

This uplift was created during the early Caledonian period and underwent substantial uplifting during the Silurian and Devonian periods. This caused a thinout of



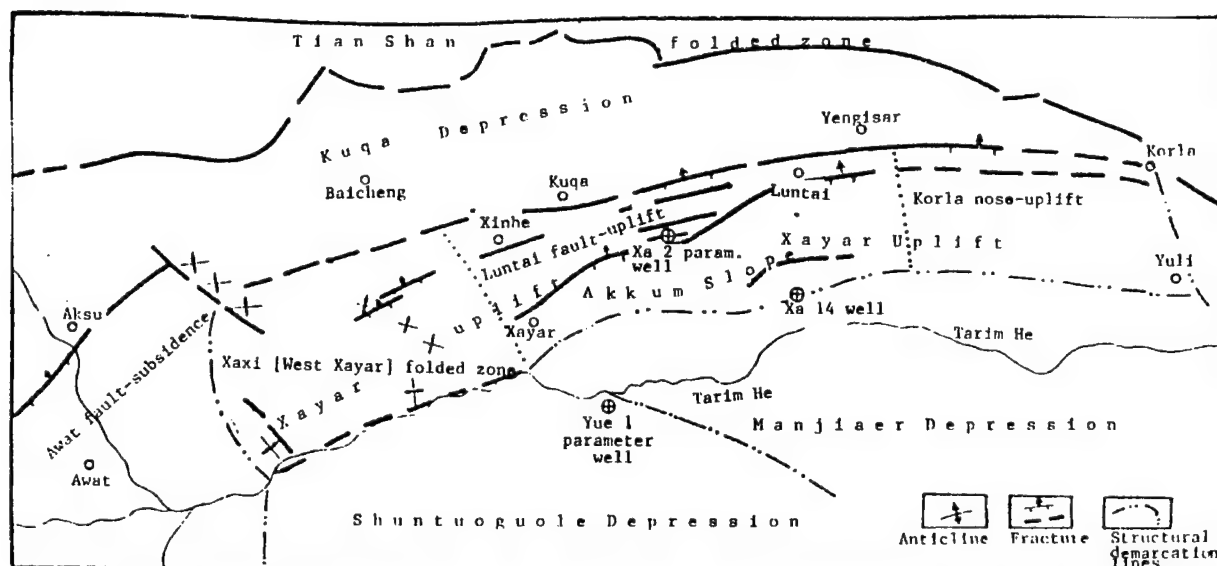


Figure 1. Structural Components of Xayar Uplift Region

sediments on the southern flank of this paleo-anticline. The uplift assumed its shape during the late Hercynian. It was in a state of latent uplifting during the Paleozoic and was a northward-tilting slope during the Cenozoic.

Xayar uplift has been subdivided into four primary structural components based on its sedimentary and structural properties (Figure 1).

**Luntai fault-uplift zone:** This extends from Xinhe County in the west to Yengisar County in the east, Ya'nan fracture to the north, and Luntai fracture to the south, covering an area of about 5,000 square kilometers. The Mesozoic and Cenozoic are fully developed. The Paleozoic is found only in certain parts of the southwest of this region. Sinian phyllite is distributed over a large area below the Mesozoic. Fractures with an ENE strike and some fault-block structures are relatively well developed in the region. There are also gentle Mesozoic and Cenozoic anticlines. Yakla oil and gas pool is located in this structural component.

**Xaxi [west Xayar] fault-folded zone:** This is located in the western part of Xayar uplift and covers an area of 8,200 square kilometers. The Mesozoic and Paleozoic are fully developed. Geophysical exploration and indications from Xa 1 parameter well show rather widely distributed interbedded volcanic rock and volcanic clastic rock in the Permian. Anticlines and fractures are relatively well-developed in the region and have two groups of strikes. One group has a northwest strike and the other a northeast strike. Combinations of structural lines of these two groups characterize this region. Oil and gas indications have been seen in many Paleozoic and Mesozoic strata at Xa 11 and Xa 13 wells, and they await additional testing.

**Akkum slope zone:** Luntai fracture is this zone's northern boundary. It extends south to near Tarim He and the western boundary is near Xayar County. It covers an area of about 10,000 square kilometers. The Mesozoic and Paleozoic are rather fully developed. It was a slope lower in the south and higher in the north during its sedimentation period, so the Paleozoic increases in thickness from north to south. Various types of unusual geologic bodies were discovered in the Carboniferous and Permian systems. High output oil and gas flows have been drilled in Akkum and Akkol structures.

**Korla nose-uplift zone:** This is located in the Yengisar-CaoHu-Korla region and covers an area of 6,900 square kilometers. The Cenozoic and a relatively thin Mesozoic directly cap the lower Paleozoic and Sinian systems and granite. The regional structural background is a slope uplifted to the east, and Kuruktag uplift is a nose-shaped structure tilted to the west. Fractures with east-west and northwest strikes are developed in this region.

#### c. Many Types of Traps

**Bedrock structural uplift weathered zone type:** Because of the formation of a residual hill-type uplift due to long-term weathering and erosion after Luntai fracturing activity uplifted the bedrock in the northern part, fracturing and weathering of the Paleozoic surface served as entrapment conditions to form oil and gas pools. Yakla Paleozoic oil and gas pool is an example.

**Anticline type:** Many anticlines were formed during the late Hercynian period in this region. The Xayar Nos 1 and 2 structures and others are examples.



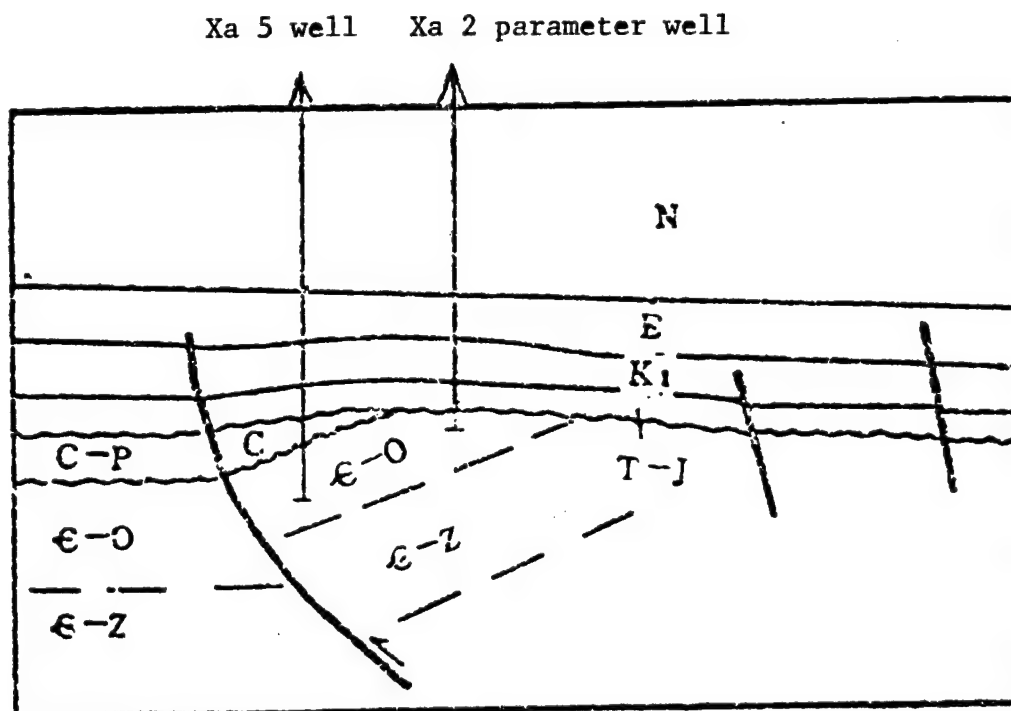


Figure 2. Illustration of Dual-Strata Structure at Yakla Oil and Gas Pool

Fracture-anticline type: Joint effects of fracturing and anticlines formed traps like Akkum structure and others, and breakthroughs have been made.

Fault-block type: High fault-block traps were formed by the effects of two fractures. This type is relatively well-developed in the northern part of Xayar uplift.

Lithologic type: Examples include various types of sand bodies, reef bodies, and so on.

### 3. Characteristics of Yakla Oil and Gas Pool

Yakla structure is located in the center of Xayar uplift and covers an area of 100 to 150 square kilometers. Work for 2 x 2 seismic measurement grids and three-dimensional seismic work has already been completed. Five deep exploration wells have been drilled and, excluding Xa 6 well where logging remains to be done, high output industrial oil and gas flows have been found at the others.

a. Structure: Yakla is located in the central part of the Luntai fault-uplift zone. It is an uplift formed by uplifting from compressive shear Luntai fracturing, and has the shape of a hill. This uplift is formed by a Cambrian-Ordovician monocline tilted to the southwest at an angle of 25° to 30°. The western flank of the structure is overlapped unconformably by the relatively thin Carboniferous system. This structure was in a continuous state of weathering and erosion since the Hercynian period and only began to subside and receive Mesozoic sediments in the late Indosinian period, so the Triassic and Jurassic systems lie at an unconformable

angle on top of the Paleozoic. There was light structural movement in the late Cretaceous which formed the Triassic and Cretaceous systems into a gentle anticline. Extension fractures developed on the northern flank of the structure during the early Tertiary.

In summary, there are two obvious unconformities (between the Carboniferous and Cambrian-Ordovician systems and the Triassic-Jurassic and Carboniferous systems) and three structural strata. The Triassic-Cretaceous gentle anticline overlaps the Paleozoic uplift, forming a dual-strata structure (Figure 2).

### b. Oil and gas-bearing characteristics

1) Multiple oil formation periods: The sources of the oil and gas flows from each of the wells and reservoir strata on Yakla structure all come from marine facies lower Paleozoic Cambrian and Ordovician system carbonate rock, and they are characterized by multiple periods of oil formation, mainly the late Hercynian period and late Xishan period. This formed three types of oil and gas pools, those generated and reservoirized in ancient rock (heavy oil from the top of the Carboniferous system), those generated later and reservoirized in ancient rock (Cambrian and Ordovician system oil and gas), and those generated later and reservoirized in the Cenozoic (Triassic and Cretaceous system oil and gas).

2) Multiple reservoir strata: Industrial oil and gas flows have now been obtained from many strata sections including the Cambrian, Ordovician, Carboniferous,

Triassic-Jurassic, Cretaceous, and other systems. Moreover, excellent oil and gas indications have been seen in the lower Tertiary Kumglim group and Jedik group.

### 3) Multiple categories of oil and gas pools

Bedrock weathering eluvial corrosion zone type: Xa 2 parameter well, Xa 7 well, and Xa 4 well found an eluvial zone several tens of meters thick with extremely well-developed vugular pore spaces and karst caves formed by long-term weathering and erosion at the top of the Cambrian and Ordovician systems. Extremely rich oil and gas accumulations are reservoirized in this zone, so every well drilled into these strata produced high outputs.

Draped anticline type: Anticlines formed by the Triassic-Jurassic and Cretaceous systems are important sites for entrapment of oil and gas. Jurassic oil and gas at Xa 4 well and Xa 7 well and Cretaceous oil and gas at Xa 5 well were controlled by anticlines.

Lithologic type: Sandstone bodies which control oil may exist in the Mesozoic on the Yakla structure.

Fault-sheltered type: Besides Luntai fracture, fractures between Xa 2 parameter well and Xa 6 well and fractures north of Xa 6 well played important roles in migration, accumulation, and distribution of the Yakla oil and gas pool.

4) Multiple phase states: The Ordovician system at Xa 2 parameter well is a light oil pool. The Cambrian at Xa 7 well and Xa 4 well is a condensed gas pool. At Xa 5 well, the Carboniferous is a heavy oil pool and the lower Cretaceous is a condensed oil and gas pool.

## II. Experiences

A. Adhering to oil and gas exploration procedures and comprehensive deployments are important ways to improve survey results.

Between the Ministry of Geology's return to Tarim in 1969-1970 and the first significant breakthrough in 1984, there were continued preparations to submit geological reserves. The overall deployment procedures involved four steps: determining oil and gas-bearing regions → selecting rich oil and gas accumulation zones → searching for oil and gas pools → exploring and evaluating.

On the basis of previous work by others and comprehensive study and assessment of geological structures and oil generation and reservoiring characteristics in Tarim Basin from 1969 to 1970, a preliminary determination was made that it was an enormous petroliferous province and that the best oil and gas prospects could be found around southwest and east Tarim depressions. From 1977 to 1979, based on the concept that structural systems controlled oil, it was felt that the east-west striking longitudinally-oriented systems and the NW and WNW-striking western-oriented regional systems were favorable regions for rich accumulations of oil and gas. It

was thus suggested that Xayar uplift (originally called Xayar slope) was a good zone for rich oil and gas accumulation as well as a region where Paleozoic oil and gas pools might be found. The third step for 30,000-square kilometer Xayar uplift was using the relationship between shear structures and ground stress as a basis for selecting Yakla and Getol structures in the center of the stress as breakthrough points for designing Xa 1 parameter and Xa 2 parameters wells. The fourth step, after the breakthrough at Xa 2 parameter well, was assessing and deriving reserves via four more wells on Yakla structure.

B. Relying on S&T progress, reinforcing comprehensive research are the keys to continued major breakthroughs.

Oil and gas survey and exploration work is complex work which involves substantial risk, is highly exploratory, and takes a long time, but in itself it has highly scientific qualities and regularities. For this reason, we should focus on and reinforce comprehensive research and use new theories in petroleum geology to guide the exploration for oil. There should be rational deductions, scientific projections, and so on in all aspects of debates over project establishment, design compilation, data analysis, survey practice, and report writing. No aspect of the whole process can be separated from comprehensive, systematic, and intensive comprehensive research work. This has been confirmed by the high rate of successful hits in exploratory drilling on Xayar uplift over the past 10 years.

C. Advanced instruments and equipment are the guarantees for improved results in oil and gas exploration.

Advanced theories for guidance by themselves are not sufficient to satisfy the requirement for attacking in the direction of the "four new things." They must be implemented with advanced instruments and equipment. Under the leadership and concern of the Ministry of Geology and Mineral Resources and the Petroleum and Maritime Bureau, the Northwest Petroleum Geology Bureau over the past 10 years has imported some advanced instruments and equipment from China and foreign countries. This greatly improved standards and results in oil and gas exploration. Of this equipment, advanced geophysical exploration instruments were obviously important.

D. Integrated exploration and implementation of contractual responsibility for items, topics, and projects is an essential measure for improving economic benefits.

Implementation of contractual responsibility according to items, topics, and projects for geophysical exploration and geology as well as exploratory drilling, and establishment of a regulation system centered on quality and achievements link the quantity and quality of achievements to economic results and are effective guarantees for carrying out large-scale integrated exploration. The advantages are:

1) They bring in competitive mechanisms. A new situation of mutual pursuit has appeared in equipment,

technologies, management, achievements, and other areas in the exploration teams from various bureaus engaged in integrated exploration over the past several years. The result has been obvious improvements in exploration progress, work quality, data, and achievements. An example is statistics on well drilling dual-start speeds which have improved from 122 days to 24 days since 1985. There also have been very rapid improvements in the quality of the wells themselves and in the core extraction rate.

2) They make use of advantages and compensate for disadvantages in technology, techniques, and production management through mutual study and joint improvements.

3) They have promoted staff construction.

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### Potential for Developing China's Wind Power Evaluated

906B0049A Beijing TAIYANGNENG XUEBAO [ACTA ENERGIAE SOLARIS SINICA] in Chinese Jan 90 (MS received 29 May 89) pp 1-11

[Article by Xue Heng [5641 2709] and Zhu Ruizhao [2612 3843 0340] of the Chinese National Meteorology Institute: "Evaluation of Potential Wind-Power Development, Utilization and Distribution in China"]

#### [Excerpts] Abstract

Based on an analysis of the mean wind-speed data collected at over 2,400 weather stations over years in China, this paper further correlates the divisions specified in the Division of Wind Energy in China and significantly improves the precision of the divisions. Based on the assigned parameters for wind machines, the capacity factors for the four types of wind machines, i.e., large, medium, small, and miniature, are calculated for over 700 points across China. In addition, a distribution map for all the capacity factors is presented. In concert with the division of wind-energy resources and the wind development effort over the past decade, the feasibility of wind-energy development, utilization and distribution is analyzed and discussed.

#### I. Introduction

Over the past decade, a great deal of work has been done in the survey, analysis, computation and division of wind-energy resources and in the development of large, medium and small wind machines. In particular, we have established a solid foundation in the production and widespread use of miniature wind machines below 1,000 watts. The 100-watt-class wind machine has a lower starting wind speed and rated wind speed. It can be installed in a wide range of areas in China. The installation of large and medium wind machines, and consequently the construction of wind power fields, depends upon wind resources.

In order to properly formulate a plan to develop and utilize wind energy and to actively and steadily develop wind-energy resources in China, the State Planning Commission asked the National Meteorology Institute to conduct a feasibility study on the development, utilization and distribution of wind energy in 1988. On the basis of modifying and correcting the "Division of Wind Energy in China"<sup>1</sup> prepared in 1983, the regional probable distribution of small, medium and large wind machines is presented.

The data used in this work includes: 1) the real-time wind measurement data collected at near 900 weather stations across China over 3 years, 2) the mean wind-speed data from 2,425 weather stations over the past 37 years, and 3) the wind-energy potential distribution data, in addition to conventional weather records, supplied by experienced weather professionals across the country.

#### II. Capacity Factors of Wind Machines

The mean wind speed was used as a basis to estimate the wind-energy potential in the area. Although the output of a wind machine depends on the mean wind speed, it is also dependent on the variance of wind speed. When a certain wind-speed probability distribution is met, it is possible to calculate the ratio of the mean output to the rated power of the wind machine. This ratio is defined as the capacity factor of the wind machine. It is a scientific indicator estimating the potential output of a wind machine installed in a specific area. [passage omitted]

1) As the rated wind speed increases, the capacity factor decreases. For instance, on the 1,000-watt wind machine curve (see Figure 1 [not reproduced]), it reaches 70 percent in northern Inner Mongolia and 70-80 percent on islands along the southeast coast. In the 10-kW plot (see Figure 2 [not reproduced]), northern Inner Mongolia drops to 50-60 percent and southeastern coastal islands also drop to 70 percent. In the 100-kW plot (Figure 3 [not reproduced]), these two areas fall off to 20-25 percent and 50-55 percent, respectively. 2) Higher-capacity-factor areas are distributed along the coast and in the three northern areas. Along the coast from Nanao, Guangdong, to Dalian in the northeast, the closer to the ocean the larger the capacity factor becomes. For instance, several dozen kilometers inland in Pingtan the capacity factor drops off to 50-60 percent. Because there are no high mountains in Shandong Peninsula and Liaodong Peninsula, the capacity factor decreases more gradually, only by 10-20 percent. Since the coast in Jiangsu runs along the northwest-southeast direction, parallel to the northwest wind in the winter and southeast wind in the summer, there is relatively less wind. As far as China's coast is concerned, it has the lowest wind power. Therefore, the capacity factor is also low. There are seven major divisions in the north where the capacity factors are high: the lower reaches of the Suhua Jiang in the northeast, the Keyouzhong League, Zhurihe, and Hailisu in Inner Mongolia, the Hexi Corridor in Gansu, and from Dabancheng to Qijiaoing and the Alashan pass in Xinjiang. Every major wind division can be further divided into several smaller zones due to local effects. For instance, the Zhurihe wind division in Inner Mongolia is further divided into five smaller zones.

In addition, capacity factors are also high in northern Qingzang Plateau, from Lijiang to Dali in Yunnan, the valley of the Hong He, and Kangding, Sichuan. However, it should be pointed out that the capacity factor drops sharply as the rated wind speed goes up in these areas. In other words, wind machines below 10 kW have some potential applications. However, the capacity factor for the 100-kW wind machine is merely 10 percent. For a 100-kW wind machine, a 50 percent or 20 percent capacity factor represents a 50-kW or 20-kW mean output. This is translated into  $4.4 \times 10^5$  or  $1.8 \times 10^5$  kWh of energy output per year. This method was developed by the American C. G. Justus and adopted by the rest of the world after he computed the capacity factors for 100-kW and 1-MW wind machines across the

United States. It clearly shows the percentage of power output for any wind machine in a specific location. This method is valuable in the site selection for a wind machine and in the computation of the economic benefits.

**Table 1. Series of Wind Power Generators**

Height Z (m)	Rated power $P_r$ (kW)	Cut-in wind speed $v_0$ (m/s)	Rated wind speed $v_1$ (m/s)	Cut-off wind speed $v_2$ (m/s)
			6	
10	0.1	3.5	8	20
			7	
10	1.0	4.0	8	20
		4.0	8	
15	10	4.5	10	20
		4.5	10	
20	50	5.0	12	20
30	100	5.0	12	25
30	200	5.0	12	25

### III. Mean Wind Speed Distribution Across China

A national mean wind-speed distribution map (see Figure 4 [not reproduced]) was prepared based on the mean annual wind-speed data collected at 2,434 weather stations across China over decades. Because the map includes the data from almost all the weather stations in China, the accuracy of the wind-speed distribution exceeds any analysis done in the past. These 2,434 weather stations represent 93 percent of the total number of counties and cities in the country. Of the stations, 800 have an annual mean wind speed of less than 2 m/s, representing 32.87 percent of the total number of stations included in the statistics; 876 stations have an annual mean wind speed of 2-3 m/s, corresponding to 36 percent of the total; 554 stations have an annual mean wind speed of 3-4 m/s, corresponding to 22.76 percent of the total; 126 stations have an annual mean wind speed of 4-5 m/s, representing 5.17 percent of the total; 39 stations have an annual mean wind speed of 5-6 m/s, corresponding to 1.6 percent of the total; and, finally, 39 stations, or 1.6 percent of the total number of stations, have an annual mean wind speed greater than 6 m/s. These 39 stations are listed in Table 2.

**Table 2. Weather Stations With Annual Mean Wind Speed Greater Than 6 m/s**

Province	Station	Wind speed	Province	Station	Wind speed
Jilin	Tianchi	11.7	Fujian	Chongwu	6.7
Shanxi	Wutaishan	9.5	Shandong	Chengshantou	6.6
Fujian	Pingtian Ocean	8.7	Ningxia	Liupanshan	6.5
Shanghai	Yushan	8.2	Fujian	Beijiao	6.4
Fujian	Taishan	8.2	Shandong	Chaoliandao	6.4
Zhejiang	Xiadachen	8.1	Hunan	Nanyuemen	6.3
Zhejiang	Nanji	7.9	Inner Mongolia	Qiandamen	6.3
Ningxia	Helanshan	7.7	Hong Kong	Henglandao	6.3
Zhejiang	Beiji	7.4	Xinjiang	Dabancheng	6.2
Taiwan	Magong	7.3	Yunnan	Taihuashan	6.2
Fujian	Mazu	7.3	Zhejiang	Kuocangshan	6.2
Zhejiang	Shengshan	7.3	Zhejiang	Tianmushan	6.2
Shandong	Qianliyan	7.2	Shandong	Qingshanda	6.2
Guangdong	Dongsha	7.1	Shandong	Taishan	6.1
Zhejiang	Shengsi	7.1	Inner Mongolia	Wulan	6.1
Fujian	Dongshan	7.1	Jiangsu	Xiliandao	6.1
Fujian	Jiuxianshan	7.1	Fujian	Qianxin	6.1
Zhejiang	Daishandao	7.1	Liaoning	Haiyangdao	6.0
Fujian	Pingtian	6.9	Liaoning	Lushun Naval Station	6.0
Zhejiang	Jushan	6.9	Inner Mongolia	Baoyintu	6.0
Zhejiang	Dongtou	6.9	Liaoning	Changhai	6.0
Shandong	Jituodao	6.9			

A comparison of the annual mean wind speed shown in Figure 4 to the "Division of Wind Energy Resources in China" reveals very good one-to-one correspondence

everywhere with the exception of the Qingzang Plateau. This kind of division has a very high degree of precision. Any area with under 2 m/s of annual mean wind speed



essentially has no wind resources. Except for some terrain, the potential of wind resources is very low and has no practical value. Areas where the annual mean wind speed is 2-4 m/s essentially coincide with the division where wind energy utilization is possible. This category is further divided into two parts. Wind energy may be utilized in areas where the annual mean wind speed is 2-3 m/s; however, it is of less value. In areas where the annual mean wind speed is 3-4 m/s, it is of higher value and has a bright future. Nevertheless, from an overall standpoint, the potential of wind power in this division is still not very high. Areas where the annual mean wind speed is 4-4.5 m/s essentially coincide the division where wind energy is relatively abundant. Obviously, it is of higher value to develop wind energy utilization in this division. Areas where the annual mean wind speed is greater than 4.5 m/s are equivalent to the division where wind energy is abundant. In this division, it is further divided into another division where the annual mean wind speed is greater than 6 m/s. It is the optimum wind energy division in China. Due to high elevation, the air density is lower in the Qingzang Plateau, which directly affects the magnitude of the wind energy. If the annual mean wind speed standard used for setting up the division is raised by one level, then it is essentially consistent with the above discussion. Moreover, this standard can be used to estimate the potential of wind energy in this area.

#### IV. Corrections

In many situations, it is not sufficient to base on existing records kept by the weather stations alone. Therefore, this paper also includes research data provided by experienced professionals in various local weather stations in order to supplement and correct for areas that could not be covered by the observation data collected by the stations or records that contain errors due to various reasons. Based on the relation between the class of the wind machine and the annual mean wind speed described above, a map was drawn to show the probable distribution points of small (1-kW-class), medium (10-kW-class), and large (100-kW-class) wind machines (see Figure 5 [not reproduced]) after taking all the factors into consideration. Major modifications of the wind energy density and annual mean wind-speed chart prepared based on weather station records are primarily made in mountainous areas with complicated terrain, such as the Xinganling Mountain Range in Heilongjiang, where the data is less representative because the weather stations are sparsely scattered. After estimating the wind profile based on research and high-altitude wind records, additional corrections and supplements were made. As another example, most weather stations in Yunnan are located near the county seats, where the terrain is relatively flat. The wind speed is in general lower than elsewhere in the province. After comparing to the data from other stations and analyzing references, some corrections were also made. Of course, there are many areas for which we still do not quite have all the facts. However, without any basis, there is no way to provide

an accurate estimate. At the present time, in order to ensure the integrity of the conclusions, we have not made any corrections or modifications; hence, the result might be on the conservative side.

#### V. Conclusions

1. The division with the potential to develop large wind machines (100 kW or above) more or less corresponds to areas with higher than 6 m/s annual mean wind speed. Across the entire country, it is limited to some regions. As far as the land area is concerned, it approximately covers 1/100 of the total area. It is primarily distributed along the southeast coastline between the mouth of the Chang Jiang and Nanao and islands near the Shandong and Liaodong Peninsula, the Hailisu Gobi desert region, Wulanchabu Plateau and Xilinguole Plain in northern Inner Mongolia, the northern Gobi near Hami in eastern Xinjiang, and the wind zones in the Alashan pass and Dabancheng in western Xinjiang. In addition, it is also scattered on high mountain tops such as the Xiao Xing'anling, Laoyeling, Zhangguangcailing and Wandashan in Heilongjiang, Helanshan and Lupanshan in Ningxia, Changbaishan Tianchi in Jilin, Wutaishan in Shanxi, Tianmushan and Kuocangshan in Zhejiang, Jiuxianshan in Fujian, Nanyueshan in Hunan, and Gaoligongshan and Taihuashan in Yunnan.

In the 100-kW wind-machine-capacity factor chart, it corresponds to areas where the capacity factor is above 0.25-0.30.

In the areas mentioned above, other than high mountain tops, the southeast coast has the highest potential for wind energy. The annual mean wind speed in coastal areas on islands generally reaches above 7 m/s, even as high as 8-9 m/s. The wind direction is also relatively stable, mostly northeast gusts. The disadvantage is this area is more susceptible to typhoons. Also, there is more salty fog in the air. These are aspects that we cannot overlook in the construction of wind machines. The northern wind-energy-abundant region covers a large area; it is also relatively open and flat. However, it is sparsely populated and has no major power grid. In the long run, this is a good place to build wind fields.

2. The potential division to develop medium wind machines (10-kW-class) more or less coincides with areas where the annual mean wind speed is above 4.5 m/s. As far as the entire country is concerned, approximately 10 percent of the land in China is suitable for developing medium wind machines. In addition to the narrow coastline, it is primarily distributed in the high plains in midwest Inner Mongolia and eastern Xinjiang, the Eerduosi high plain and Hulanbaier high plain in Inner Mongolia, the wind zone in western Eerqisi He valley and the western Zhungeer basin in Xinjiang, Tongyu in western Jilin, the Sanjiang plain and Songnen plain in Heilongjiang, central Tibet, and other scattered areas in the Subei plain, Taihu lake area and the mountains in Yunnan.

In the capacity factor chart for the 10-kW wind machine, this division corresponds to areas with a capacity factor of greater than 0.3. The wind in areas is highly seasonal, and is very strong in some months. With the exception of a few months of low wind, the operating efficiency of the wind machine can be significantly improved.

3. Based on our recent experiments to promote wind machines, areas with potential for the small wind machine (1-kW-class) correspond to places where the annual mean wind speed is above 3 m/s. Relatively, some wind machines are not operating at very high efficiency in this division. In the 1-kW wind-machine-capacity factor chart, it is equivalent to areas where the capacity factor is above 0.25. We chose 0.25 at 10 meters as the capacity factor limit for the installation of a small wind machine. This is related to the seasonal weather. The division is distributed in areas with strong seasonal wind activities. Therefore, there is sufficient wind in several months for the small wind machines to operate at high efficiency. After taking the supply and demand of energy in the area into account, it is still socially and economically beneficial to develop wind energy in those areas.

This division covers a large area, approximately 40 percent of the country. It covers the entire northeast provinces with the exception of some low valleys in the Daxinganling and Changbai mountains, most of Inner Mongolia, the northern part of Beijing, Hebei, Shanxi, Shaanxi, Ningxia and Gangsu, the midwestern part of Qinghai, most of Tibet with the exception of the Yalu-zangbu Jiang valley, and the two basins and the Aertaishan mountain area in Xinjiang. In addition, it also includes the eastern part of Tianjin, Hebei, Shandong and Henan; Jiangsu; northern Anhui to Jiangxi; the lakes region in Hubei; Zhejiang; Fujian; coastal areas in Guangdong and Guangxi; and the northeastern part of Yunnan.

4. The 100-watt-class miniature wind machines may be installed in areas with an annual mean wind speed of below 3 m/s. The lower boundary of the division is located at the 2-m/s line in the national annual mean wind-speed map. This division is slightly larger than that for the small wind machine. From the standpoint of the yearly operating efficiency of the wind machine, this specification is on the low side. However, considering the fact that energy is in extremely short supply in many areas, in order to slow down ecological damage and to incorporate wind energy as an integral part of new energy resources, this specification is very practical. From the angle of resources, although the annual mean wind speed is only 2-3 m/s, there is nonetheless still considerable potential in the winter months because of the strong seasonal wind in many areas (especially in the North and West). It is still quite valuable to take full advantage of these resources.

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#### Sino-U.S. Solar Venture Planned

40100045A Beijing CHINA DAILY (Business Weekly) in English 23 Apr 90 p 4

[Article by staff reporter Yang Xiaoping]

[Text] A major petroleum corporation in China and the World Energy Foundation in the United States are paving ways for a Sino-American joint venture to develop a series of advanced solar energy products.

A letter of intent was signed in Beijing on Wednesday by China Petroleum Engineering Construction Corporation (CPECC) and the Massachusetts-headquartered Photo-therm Inc/World Energy Foundation.

Officials from the two sides showed great interest in their future cooperation in developing, manufacturing and selling solar energy products in the United States, China and, if possible, other regions of the world.

The American corporation possesses certain patents for solar utilization technologies. "We have been greatly interested in the new technologies which can turn solar energy into electricity effectively," said Shan Yongfu, president and vice-chairman of the board of CPECC.

A light-electric power converter made of a new plastic material was invented by Alvin M. Marks, chief scientist and director of Phototherm Inc in 1986. The device can convert 60 to 80 per cent of the energy from sunlight it receives into electricity. The efficiency for usual materials is only 15 per cent.

Chen Liming, an associate professor from the Electrical Engineering Department of Zhejiang University who has carried out solar energy research for years, explained that the new material was not difficult to manufacture and would incur quite low production costs.

Chen said that one third of China's total land area enjoyed abundant sunshine, which would provide great potential for solar energy technology development.

Apart from the light-electric power converter, the joint venture also expects to develop a solar cooker, also Marks' patent, which can store the heat absorbed from sunlight.

Gerard J. Aitken III, now president of the foundation which is based in Massachusetts and New York City, said that she and her late husband conceived the idea of developing solar energy technology in 1982 when they attempted to do something positive for developing countries, especially those areas whose poor farming conditions resulted from deforestation and soil erosion. "Solar energy poses possibilities," she said.

Invited by the State Science and Technology Commission, Aitken and Marks came to China to give lectures on their new solar technology in 1988.

"We really hope that our solar energy technology can help the people in China and other developing countries," Aitken remarked.

A senior business executive official from CPECC said that they expected to work out specific details about the joint venture after they visit the United States next month.

In another project with China, Aitken invited 16 Chinese farmers from South China's Fujian Province to her 83-acre model village in Athol, Massachusetts, to learn how to use solar greenhouse powered by hydroponics, a new technology. Aitken hoped that the advanced solar technology and vegetable cultivation technology from Beijing Vegetable Research Centre would be demonstrated by the Chinese farmers, who are planning to leave for the model village soon.

### **Solar Energy Brightens Lives—And Saves Fuel Too**

40100048A Beijing CHINA DAILY (Shanghai Focus)  
in English 30 Apr 90 p 1

[Article by staff reporter Chen Qide]

[Text] Solar energy, a rising power source, has made a great contribution to improving people's lives in the city.

More and more civilians have become accustomed to this once unfamiliar source, and about 300,000 people can now enjoy hot baths powered by 75,000 square metres of solar energy water heaters, according to Zhu Chengming, vice secretary-general of the Shanghai Solar Energy Society.

By the end of 1988, the city had turned out 150,000 square metres of the heaters, accounting for 40 per cent

of the country's total. Half of them are employed in the country's 28 provinces, municipalities and autonomous regions.

Statistics show that the country has more than 60 factories producing water heaters with an annual output of one million square metres.

Zhu said the use of solar energy was not only convenient for civilians who had no chance to enjoy hot water in public bathrooms, but also saved the city annually 30,000 tons of coal, an energy source in short supply.

The adoption of solar energy also helped to purify the city's air, he added.

A survey conducted in 1979 showed that the city used more than 10 million tons of coal and 5.8 million tons of oil every year, emitting 300,000 tons of sulphur dioxide into the atmosphere. "This is really harmful to people's health," said Zhu.

Shanghai's research into solar energy started in the 1950s.

The city also produces solar cookers. So far 150,000 are used by domestic consumers while 100,000 square metres of the devices have been installed in more than 240 buildings.

Farmers in the country's western rural areas, including Gansu, Qinghai, Xinjiang and Tibet, use a total of 80,000 solar cookers.

In the past 10 years, 300 million kilograms of fuel had been saved, according to Zhu.

Lack of energy was a major headache to most regions in the country, said Zhu, who is also managing director of the country's Energy Information Organization.

He said industrial enterprises consumed around 16 million tons of coal a year, and the State provided only about 20 per cent of their energy needs. "Therefore, an acute shortage of energy is facing them," he said, "and a good solution is to make full use of solar energy."

The city was also the country's first producer of the silicon solar battery, which has powered four satellites since 1969. It also supplied batteries of this kind for its navigation marks, railways, agriculture, and other purposes.

Zhu said that since solar energy now had bright prospects, it should become the main energy source for human beings in the future.

He predicted that after a few years, the development of solar energy in the city would be able to provide non-fuel cooking for the country's 80 million households.

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